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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

THE PRINCIPAL'S REPORT* 1932-1933.

THE Principal, upon whom the King, who is the Patron of the College, has recently conferred the honour of Knight Bachelor in recognition of his services to Tropical Agriculture, once more reviews its activities during the course of a year which showed little diminution in financial anxiety due to the world-wide depression. It is gratifying to record that by means of rigid economies in the votes of all Departments, and the continued contributions from members of the Staff and outside sources, the College is able to show a balance of income over expenditure. In spite of such economies, in which almost every departmental vote has shown a saving on the estimates, the number of original articles published by members of the staff is greater than ever before, indicating that whilst expansion of activities may be somewhat curtailed, the status of the College as a central research station is being satisfactorily upheld.

Notable amongst the several important changes in the staff during the year was the retirement of Professor H. A. Ballou, whose thirty years of distinguished service in the cause of West Indian agriculture was recognised by the title of Commander of the Order of the British Empire, conferred on him by the King. Mr. Ballou continued to act as Commissioner of Agriculture to the Advisory Department up to the time of his retirement in June, and made frequent tours to the Leeward and Windward Islands. Mr. G. A. Jones, then Assistant Commissioner, who later was appointed in his stead, also travelled freely throughout the islands where agricultural advice is much appreciated by the local officers. Similarly the services of the Marketing Officer, rendered available for the development and expansion of the markets of these dependencies through a grant from the Colonial Development Fund, have been esteemed, and extended for a further year. The importance of this aspect of the Advisory Department's work stimulates a hope that means will be found to place the appointment on a permanent basis.

Sugar-cane research is becoming more highly organised, and its scope widened by the formation of Investigation Committees in both Antigua and St. Kitts, where the sugar planters and factories have pooled funds for carrying out experiments under the expert guidance of Mr. P. E. Turner, of the Trinidad Sugar Cane Investigation Committee, who will make periodic visits to these islands from

* The Imperial College of Tropical Agriculture. The Principal's Report for the year 1932-33, and the Accounts for the year ended 31st August, 1933.

his headquarters at the College. Dr. McIntosh, chief officer of the Central Sugar Cane Breeding Station in Barbados, is co-operating actively with these committees. Other work in this connection included continuation of biological control measures, land settlement schemes, and the organisation of the sea island cotton industry and Peasants' Fruit and Vegetable Bureaux.

On the academic side, a larger number of students than hitherto was in residence, being fifty-one as compared with forty-five in the previous year. These consisted of twenty-four Diploma students and twenty-three taking the Post-Graduate course—the latter composed of fourteen Colonial Agricultural Scholars, four under the Cotton Growing Corporation, two private students from English universities, one officer of the Colonial Service, two Gold Coast Government students, graduates of California, and one from South Africa attending the Sugar Technology course. The Diploma students came from eight colonies of the Caribbean area, and one each from Colombia and England. These facts are mentioned because they show the ever-increasing range of appeal which the system of training here adopted makes to the tropical dependencies of the Empire and foreign countries. The curricula in all courses remained essentially the same, but in the Post-Graduate course the number of lecture hours has been reduced and greater stress laid on practical demonstrations and field excursions, as recommended by the Conference of Colonial Directors of Agriculture in 1931. Rules and regulations governing the revision of the Diploma course and the introduction of a two-year Certificate course were completed, approved by the Governing body, and circulated to the Governments of the British Colonies in the Caribbean area who in general reported favourably on the change.

The scientific officers of the staff have continued their investigations on various aspects of the four major crops: *viz.*, sugar-cane, cacao, bananas and citrus; though parallel lines of research on other crops have from time to time been followed whenever these gave promise of elucidating particular points arising from the main issues.

The cacao crop is being intensively studied by three officers—one soil chemist and two botanists—under a scheme financed by various cacao-growing colonies, and certain cocoa and chocolate manufacturers, and the results of their investigations to date have already been published in three Annual Reports. The improvement of planting material by selection, both for quality and yield, has been shown to be capable of giving very marked results, and a wealth of valuable data has already been collected from some 1,200 trees in Trinidad, upon which the future scheme of isolating a few high-yielding strains of good quality is being founded. Initial selection is based on the number of pods required to make one pound of dry cacao—trees from which more than seven and a half pods must be picked to give one pound of dry cacao are being disregarded—and subsequent observation will eliminate from the remainder all but the heaviest bearers on the basis of number of pods per tree. Another important fact brought to light in this connection is that in general large pods contain large beans, and not a proportionately greater number of small ones, so that yield selection by the method evolved will, in so far as quality is determined by plumpness of bean, automatically result in improvement of both factors The development of a satisfactory technique of vegetative propagation is an essential corollary to the establishment of improved types, and progress along this line of enquiry is likewise reported. Ecological and growth studies of the cacao tree are probing new and very promising fields of investigation, and already the detailed comparison of soil and atmospheric factors prevailing under good and bad cacao-growing conditions is beginning to allow conclusions to be drawn. Amongst other things the chemical analysis of cacao beans under these two ecological environments is beginning to shed some light on the problem of Thrips attack. The Economics Department of the College, in co-operation with the officers of the Cacao Research scheme, has continued its detailed economic surveys of certain Trinidad cacao estates, and from the figures and field maps which have been constructed, the relation of soil, genetics, age and other factors to the ultimate yield and profits of the estates has been established.

Banana breeding work has made steady advance since its inception ten years ago, and the mass of information accumulated from its diverse lines of attack are now beginning to present certain fundamental principles upon which banana breeding can be carried out, and applied even to local problems. A stage has been reached where direct breeding on Gros Michel can be handed over to the Jamaica Department of Agriculture, and this is now in operation. Meanwhile the taxonomic, cytological and breeding work continues; varieties introduced under about 130 separate names have, by intensive observation, been reduced to 25 standard types, thus greatly simplifying the breeding problem. Amongst these, varieties such as Lacatan, Bumulan, Giant Fig, &c., have been proved to be practically identical with or closely allied to the Cavendish group. This group has given consistently negative breeding results, and so has been abandoned for that purpose. Although research of this nature is intrinsically long-range in character, the outcome shows promise of yielding early economic results. The most promising seedling raised up to the present—I. C. 2—is both immune to Panama disease, and seedless; so that the present field trials of this new variety will decide its commercial possibilities. Storage trials by the Low Temperature Research Department have continued to render valuable service in comparing and assessing the commercial value of banana varieties. Trials with I.C. 2, for example, indicated the similarity in many respects of that variety to Gros Michel. A detailed investigation carried out by the officers concerned into methods of improving consignments of crated bananas despatched from Samoa to New Zealand was

completed, and a report embodying their recommendations has been sent to the New Zealand Government at whose specific request the work was undertaken. The scope of this department has recently been considerably widened in pursuance of the recommendations of the Empire Marketing Board, approved by the Secretary of State, that it should be extended so as to include other tropical fruits and products besides bananas. Preliminary results have already been obtained and published from storage trials on tomatoes, West Indian limes and other citrus fruits, avocado pear and various vegetable crops.

Sugar-cane problems have received the attention of more than one department. The variety trial of thin canes, using Uba as the standard of comparison, has been continued by the College Department of Agriculture, and is now nearing completion. This Department also, in addition to many experiments on short-term crops conducted in co-operation with post-graduate students, is carrying out investigations into composts, and the manufacture of artificial organic manures from the waste materials of the farm. Fodder grasses are being compared for their feeding quality with a view to eliminating the grazing of stock on the deficient pastures usually met with in the wet tropics. The permanent manurial plots are beginning to yield useful results, such as the discovery that potash deficiency often results from continuous cultivation of the light soils found on the farm; whilst the application of modern methods of statistics to field experimentation and farm management has already evinced much interest from outside sources by the publication of articles dealing with the subject. The Chemistry Department has contributed its full share to some of these and other problems. Soil surveys of Antigua, Jamaica and St. Vincent—with others projected or in course of survey—have been undertaken, and their publication, involving much time-consuming labour, has been appreciated fully by the colonies concerned and has led to requests for similar surveys from others. The study of the soil changes—accompanied usually by deterioration—that are involved when forest soil is opened up for cultivation is yielding important data of interest not only to the Trinidad Forest Department which is in active collaboration in this work, but to the tropical agriculturist for whom the problem of the disadvantages attendant on "shifting cultivation" is ever a matter of controversy and pertinent enquiry. The fertility, liming and manurial experiments on sugar-cane now cover a wide field of research, thanks to the funds made available by Imperial Chemical Industries, Ltd., for that purpose. Among many important points elucidated, it has been shown that pen manure alone fails to maintain the fertility of the soil as regards its nitrogen and potash content, and that these elements must be supplemented by the addition of artificials; but nevertheless, there are indications that a balanced dressing of artificials alone will give larger yields at a lower cost of production than 20 tons of pen manure supplemented by 4 cwts. of ammonium sulphate. The phosphate status of Trinidad cane soils appears to need little attention from the grower.

The activities of the Mycology Department have been as varied as they have been fruitful of results. Control of scab disease of sour orange has been established by means of giving partial shade to the seedlings. Stripe disease of maize has been shown to be a virus, and its insect vector has been determined. The new spray—"Sulphemulsol"—a combined insecticide and fungicide, has given promising results in trials on certain types of disease and pest, and is now being manufactured by Trinidad Leaseholds Ltd. who collaborated in its formulation. Witchbroom control likewise is receiving the earnest attention of this Department, as well as many other diseases of minor crops. The Entomology Department also has a variety of problems in hand; in particular biological control of froghopper is under intensive study, whilst the ecology and bionomics of the insects concerned are not being neglected.

Space prevents the enumeration of all the activities of College research work, but it is hoped that sufficient has been said to indicate not only their wide scope, but also their direct economic significance and the unlimited possibilities for the future. That progress has been achieved nobody who reads this report will doubt; meanwhile the work of consolidation and extension continues.

REPTILE SKINS IN COMMERCE.

A few years ago the use of the skins of reptiles in the manufacture of shoes was regarded as a whim of the moment, but now the view is strongly held by the leather trade and by the technical experts in the industry that the skins are established as a raw material for leather production on as permanent a basis as goat, calf and sheep skins. This is the view expressed by the sub-committee appointed by the Imperial Institute advisory Committee on Hides and Skins (*Bull. Imp. Inst.*, 31, No. 2, 160; 1933). The change in outlook has taken place since 1926, when reptile skins were employed only in the making of luxury articles; now they are used for the mass-production types of shoes, as well as for bag and fancy leathers. Some of the advantages of reptile leather are that it is hard-wearing, stronger than sheep, goat or even calf skins; it shows great variety of pattern and design; and it takes colour readily. But the demand has been telling upon reptile populations in various tropical countries. In 1932, India exported 2½ million reptile skins; in 1931 more than two million came from the Dutch East Indies; and serious depletion has occurred in the stock of the North American alligator, the edible terrapins of the United States, and the green turtle, the last being valued as food.—(*Nature*, Vol. CXXXIII, No. 3354, 1934, p. 206.)

A NOTE ON THE VALUE OF CORRELATION AND REGRESSION IN STATISTICAL ANALYSIS—*Continued.*

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Introduction.

In the 1933 volume of *Tropical Agriculture*, there appeared a paper by the present writer, entitled "Experimentation and Applied Statistics for the Practical Agriculturist"*. This was intended as an elementary guide to the agricultural student who might find it advantageous to apply modern statistical methods to his experimental results, but who lacked the necessary mathematical training to utilise effectively the more technical books on statistics. Recent inquiries have shown that the scope of the article could be extended with profit, and are responsible for the present attempt to widen the field of information. As in the previous paper, all explanations have been worded as simply as possible, and the subject has been treated strictly from the practical view-point. Mathematical proofs have been omitted, and descriptions are limited to the application of accepted theorems to experimental results. The examples cited are intended merely to illustrate the progressive stages in the analytical methods detailed in the text. In order to make the calculations easy to follow, the data have been confined, as far as possible, to simple integers, and the number of variables recorded has been cut down considerably below the point in experimental work at which statistical treatment is merited. These examples must not be regarded as at all representative of the material which the statistician normally has to work with, and they are not meant to illustrate the type of records required for accurate analysis of any of the problems exemplified. Furthermore, in order to avoid tedious repetition, it is assumed that the reader understands the elementary statistical theories detailed in the previous paper, and is familiar with the technicalities used therein.

Calculation of the Coefficients of Correlation and Regression.

These are terms by now familiar to most scientific workers, but the estimation of their statistical value is possibly not so well known. Therefore, the following brief and very elementary explanation of the method of calculating the coefficients of correlation and regression is given as essential to a thorough understanding of the second half of the paper.

In practically all research, a large number of interacting factors have got to be taken into consideration before a comprehensive knowledge of the subject under examination can be obtained. These factors are frequently interdependent to a greater or less extent; an alteration in one tends to produce some corresponding change in the other, *e.g.*, the reaction of temperature changes on fungal growth. In Physics and Chemistry, the relationship is often so complete that a change in one factor produces an exactly proportionate change in the second. With most biological problems the affinity is much less marked, and it is often of great advantage if some fairly accurate estimate of the degree of interdependence can be made. This can be obtained by calculating the coefficient of correlation.

Example I.

Consider the following data, illustrating the effects of rationing on the milk yield of dairy cattle (*vide* Table I). These records represent the average daily yield of a herd of thirty Ayrshire cows. The quantity of concentrate ration per head per day varied from 1 to 6 lb., each animal being kept on the same ration for the whole of the experimental period. It is desired to ascertain for these data the degree of association or correlation, if any, between, the milk yield and the size of the ration.

Variance is a term used to denote, for any series of records, the mean sum of squares, *i.e.*, the sum of squares divided by the number of degrees of freedom. The parallel term in the case of the sum of products has been called the **Covariance.** In the above example there are 30 pairs of corresponding readings from which the correlation coefficient is calculated. Therefore the covariance $= \frac{+80}{29} = +2.76$, and the value of the correlation coefficient is equivalent to the fraction

$$\frac{\text{Covariance}}{\sqrt{\text{Variance of x} \times \text{Variance of y}}} = +.61.$$

The coefficient of correlation, r, will always lie between $+1$ and -1. It is not affected by the units in which the variables are measured. If r is zero, the two factors are independent of one another, while the nearer r approaches to unity, $+$ or $-$, the greater the degree of correlation. The sign of r will be the same as that of the covariance. A positive value of r shows that an increase in one factor tends to produce a corresponding increase in the second. A negative correlation on the other hand proves that an increase in the one factor will normally correspond to a decrease in the second. In order to ensure that the estimate is reasonably accurate, the coefficient of correlation should be based on a relatively large number of variables, 500 to 1,000 or more. For even 100 variables, a value of r equal to $\pm.3$ might be obtained purely by chance from two entirely independent characters. In many experiments the number of records procurable is limited, and in such cases, the correlation coefficient is of little significance unless it has a value of not less than $\pm.6$.

* *Tropical Agriculture*, Vol. X, Nos. 10, 11 and 12.

Table I.

Showing the Concentrate Ration and the Resultant Average Daily Milk Yield Per Animal.

Daily Concentrate Ration in lb. x	Average Milk Yield per Animal in Half-Gallons. y.	Deviation of x from Mean of x.		Deviation of y from Mean of y.		$d_x \times d_y$.	
		d_x	d_x^2	d_y	d_y^2		
		+ −		+ −		+	−
1	1	2.5	6.25	4.2	17.64	10.5	
1	3	2.5	6.25	2.2	4.84	5.5	
1	5	2.5	6.25	.2	.04	.5	
1	2	2.5	6.25	3.2	10.24	8.0	
1	2	2.5	6.25	3.2	10.24	8.0	
2	4	1.5	2.25	1.2	1.44	1.8	
2	5	1.5	2.25	.2	.04	.3	
2	3	1.5	2.25	2.2	4.84	3.3	
2	6	1.5	2.25	.8	.64		1.2
2	4	1.5	2.25	1.2	1.44	1.8	
3	2	.5	.25	3.2	10.24	1.6	
3	3	.5	.25	2.2	4.84	1.1	
3	5	.5	.25	.2	.04	.1	
3	6	.5	.25	.8	.64		.4
3	6	.5	.25	.8	.64		.4
4	4	.5	.25	1.2	1.44		.6
4	7	.5	.25	1.8	3.24	.9	
4	5	.5	.25	.2	.04		.1
4	6	.5	.25	.8	.64	.4	
4	8	.5	.25	2.8	7.84	1.4	
5	9	1.5	2.25	3.8	14.44	5.7	
5	3	1.5	2.25	2.2	4.84		3.3
5	4	1.5	2.25	1.2	1.44		1.8
5	8	1.5	2.25	2.8	7.84	4.2	
5	7	1.5	2.25	1.8	3.24	2.7	
6	6	2.5	6.25	.8	.64	2.0	
6	11	2.5	6.25	5.8	33.64	14.5	
6	11	2.5	6.25	5.8	33.64	14.5	
6	2	2.5	6.25	3.2	10.24		8.0
6	8	2.5	6.25	2.8	7.84	7.0	
				+31.4 −31.4		+95.8	−15.8
Totals 105	156	0	87.5	0	198.8	+80	

Sum of Squares for Ration, *i.e.*, S.S.x = 87.5

Sum of Squares for Milk Yield *i.e.*, S.S.y = 198.8

Sum of Products *i.e.*, S.P.xy = +80.0

Correlation Coefficient, r, $= \dfrac{\text{Sum of Products}}{\sqrt{\text{S.S.}x \times \text{S.S.}y}}$

Therefore r in Example I $= \dfrac{+80}{\sqrt{87.5 \times 198.8}} = +.61$

In the above example, there is an apparent positive correlation of .61, demonstrating that an increase of the ration will on the average produce an increase in the milk yield. This is a scientific truth which has been familiar to stock breeders for some considerable time. The correlation of .61 is, however, not a very high one and the recorded data are obviously too limited to provide any certain measure of the degree of association between milk yield and ration.

Regression.

In addition to estimating the actual correlation, it is often desirable to ascertain what effect, on the average, a given change in one factor will produce on the second. For example, for the above data, it might be of practical value to know what average increase in milk yield can be expected from an addition of 1 lb. per head to the concentrate ration of the stock as a whole. The recorded data from Table I has been used to draw up the following chart in which the ration is plotted against the milk yield (*vide* Table II). Each square shows the number of animals giving the same milk yield for any given weight of concentrate.

The last row and last column on this Correlation Table, show respectively the average daily yield of milk resulting from each concentrate ration fed, and the average number of lb. of concentrate required to produce any given milk yield. These values have been used to plot the two graphs AB and CD in Diagram I. The graphs have been drawn from a very limited number of records and in consequence are somewhat irregular in character; they apparently tend to be linear and the dotted lines, arbitrarily

Table II.

Correlation Table.

Milk Yield in Half-Gallons.	Rations in Lb. 1	2	3	4	5	6	Total of Rows, *i.e.*, Number of Animals giving the same Milk Yield (Frequency).	Total Daily Ration fed to these Animals (lb).	Aver. Number of lb. of Concentrate req. to produce each given Milk Yield, *i.e.*, lb. / Frequency.
1	1						1	1	1
2	11		1			1	4	11	2.75
3	1	1	1		1		4	11	2.75
4		11		1	1		4	13	3.25
5	1	1	1	1			4	10	2.50
6		1	11	1		1	5	18	3.60
7				1	1		2	9	4.50
8				1	1	1	3	15	5.00
9					1		1	5	5.0
10							0	—	—
11						11	2	12	6.0
Total of Columns, *i.e.*, No. of Animals on the same Ration (Frequency)	5	5	5	5	5	5	30		
Total Milk Yield of all Cows on the same Ration (Half-Gallons)	13	22	22	30	31	38			
Aver. yield per Cow for each Concentrate Ration, *i.e.* Half-Gallons / Frequency	2.6	4.4	4.4	6.0	6.2	7.6			

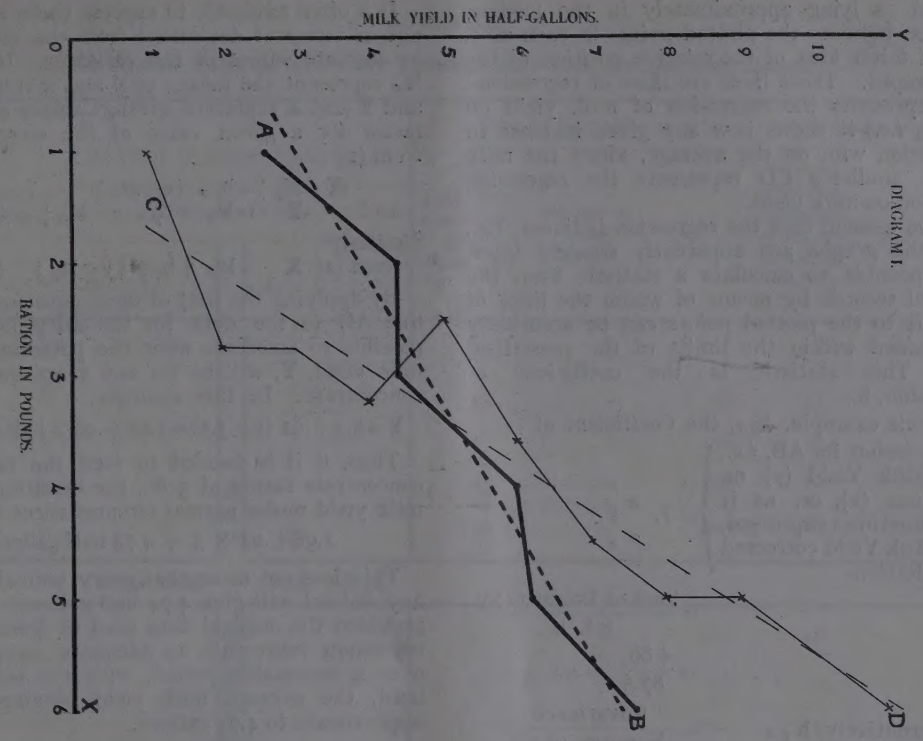

DIAGRAM I.

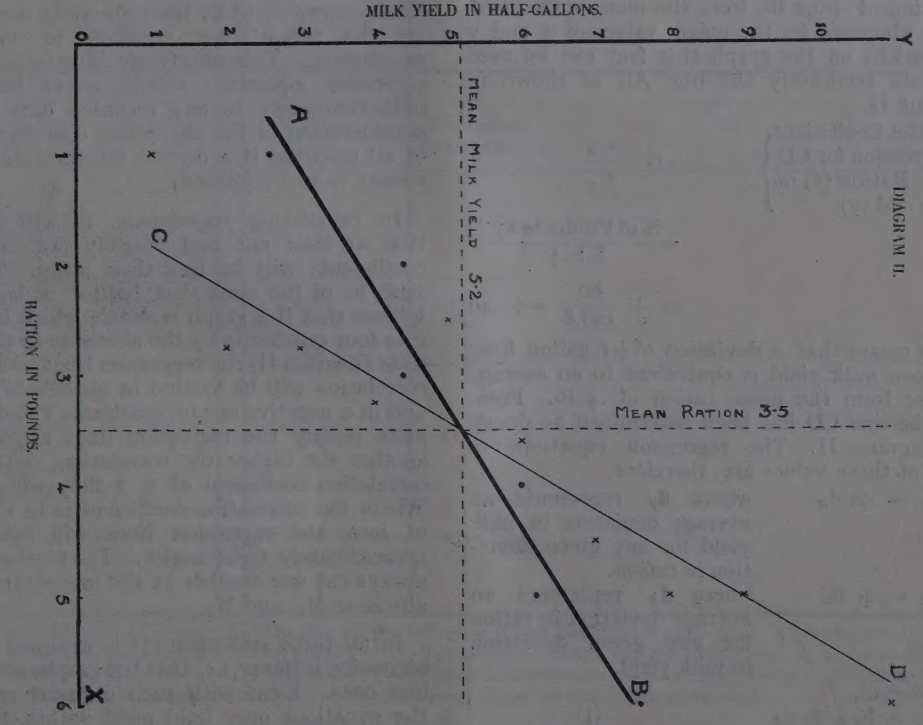

DIAGRAM II.

located as lying approximately in the median position between the plotted points in each case, give a fairer idea of the relative position of the two graphs. These lines are lines of regression; AB represents the regression of milk yield on ration, *i.e.*, it shows how any given increase in the ration will, on the average, affect the milk yield: similarly CD represents the regression of ration on milk yield.

If we assume that the regression is linear, *i.e.*, that the graphs are apparently straight lines, it is possible to calculate a statistic from the original records by means of which the lines of best fit to the plotted points can be accurately determined within the limits of the prescribed data. This statistic is the coefficient of regression, b.

In this example, $b_{y,x}$, the Coefficient of Regression for AB, *i.e.*, of Milk Yield (y) on Ration (x), or, as it is sometimes expressed, of Milk Yield corrected for Ration

$$= r.\frac{\sigma_y}{\sigma_x}.$$

$$= \frac{\text{Sum of Products xy}}{\text{S.S. x}}$$

$$= \frac{+80}{87.5} = .92$$

Alternatively, $b_{y.x}$ $= \dfrac{\text{Covariance}}{\text{Variance of x}}$

This shows that for AB a deviation from the mean ration of +1 lb. is equivalent to an average deviation of +.92 lb. from the mean milk yield. If the abscissae for the mean values of x and y are marked on the graph this fact can be used to locate accurately the line AB as shown in Diagram II.

$b_{x.y}$, the Coefficient of Regression for CD, *i.e.*, of Ration (x) on Milk Yield (y)

$$= r.\frac{\sigma_x}{\sigma_y}$$

$$= \frac{\text{S. of Products xy}}{\text{S.S. y}}$$

$$= +\frac{80}{198.8} = +.40$$

This means that a deviation of +1 gallon from the mean milk yield is equivalent to an average increase from the mean ration of .4 lb. From this, the line CD has been determined as drawn in Diagram II. The regression equations in terms of these values are, therefore,

$\mathbf{d}_y = .92\ d_x$ where $\mathbf{d}_y$ represents an average deviation in milk yield for any given deviation in ration.

and $\mathbf{d}_x = .40\ d_x$ where $\mathbf{d}_x$ represents an average deviation in ration for any given deviation in milk yield.

In general,

$\mathbf{d}_y = b_{y.x} \times d_x$ (1)

$\mathbf{d}_x = b_{x.y} \times d_y$ (2)

It is often advisable to express these equations, not in terms of deviations from the means, but in absolute values of the variables. If M_y and M_x represent the means of y and x respectively, and $\mathbf{Y}$ and $\mathbf{X}$ represent average values of the one factor for a given value of the second, then, from (1)

$$(\mathbf{Y}-M_y) = b_{y.x}\ (x-M_x)$$

and $\mathbf{Y} = M_y + b_{y.x}(x-M_x)$ (Line AB)

Similarly

from (2), $\mathbf{X} = M_x + b_{x.y}\ (y-M_y)$ (Line CD)

By applying the first of these equations for the line AB to the data for the dairy herd, it is possible to ascertain what the potential average milk yield, $\mathbf{Y}$, will be for any given quantity of concentrate. In this example,

$\mathbf{Y} = 5.2 + .92\ (x-3.5) = 1.98 + .92$ x half-gallons.

Thus, if it is decided to feed the herd on a concentrate ration of 3 *lb.*, the resulting average milk yield under normal circumstances should be

$$1.98 + .92 \times 3 = 4.74 \text{ half-gallons}$$

This does not mean that every animal or even any animal will give 4.74 half-gallons, but that, provided the original data used to determine the regression represents an adequate sample, then over a reasonable period, with the same dairy herd, the average milk yield obtained should approximate to 4.74 gallons.

Theoretically the equation for CD might be used to estimate from a given yield the ration being fed to the herd. Actually it is of little practical significance, as, while the milk yield does depend on the ration, the corollary is, of course, nonsensical. This effectively illustrates that the regression equations should never be applied indiscriminately to any recorded data; careful consideration of the characters concerned is first of all essential if a correct interpretation of the results is to be formed.

In calculating regressions, it will be found that at least one and possibly both regression coefficients will be less than unity. They will both be of the same sign, both + or both—. It follows that if a graph is drawn which is divided into four quadrants by the abscissae of the means (*vide* Diagram II) the regression lines in a positive correlation will be located in quadrants 2 and 4, and in a negative one in quadrants 1 and 3. The more closely the regression lines approach one another the higher the correlation, until with a correlation coefficient of $\pm$ 1 they will coincide. Where the correlation coefficient is in the region of zero, the regression lines will intersect at approximately right angles. The regression lines always cut one another at the intersection of the abscissae M_x and M_y.

In all these statements it is assumed that the regression is linear, *i.e.*, that the graphs are straight line ones. Even with such a linear regression, the equations only hold good within the range of the recorded data.

Table III.

Correlation Table in which the Variables have been grouped into Classes.

Mean Yield in Half-Gallons. Classes (y).	Mean of Class,	Rations in pound Classes (x) — Mean of Class: 1	2	3		4	5	6	Sum of Squares of y. — Total Frequency in each Row. (f_y)	Square of Row Mean. y^2	$f_y \times y^2$	Sum of Products. — Sum of Row Frequencies × corresponding Ration $\Sigma(f \times x)$	$\Sigma (f \times x) \times y$
	1	1							1	1	1	1	1
	2	2		1				1	4	4	16	11	22
	3	1	1	1			1		4	9	36	11	33
	4		2		3.5 lb.	1	1		4	16	64	13	252
	5	1	1	1		1			4	25	100	10	50
	Mean of Class.	**Mean Milk**				**Yield 5.2 lb.**							
	6		1	2	Mean Ration	1		1	5	36	180	18	108
	7					1	1		2	49	98	9	63
	8					1	1	1	3	64	192	15	120
	9						1		1	81	81	5	45
	10								0	100	0	—	—
	11							2	2	121	242	12	132
Sum of Squares of x.	Total frequency in each column (f_x)	5	5	5		5	5	5	30 (Number of Variables.)		1010 (B)		626 (C)
	Square of Column Mean (x^2)	1	4	9		16	25	36					
	$f_x \times x^2$	5	20	45		80	125	180	455 (A)				
	Sum of Column Frequencies x Corresponding Milk Yield $\Sigma (f \times y)$	13	22	22		30	31	38					
	$\Sigma (f \times y) \times x$	13	44	66		120	155	228	626 (C)				

From (A), S.S. Ration (x) = 455 − (Total No. of Variables × Mean Ration²) = 455 − 30 × 3.5^2 = 87.5.
From (B), S.S. Milk Yield (y) = 1010 − (Total No. of Variables × Mean Yield²) = 1010 − 30 × 5.2^2 = 198.8.
From (C), Sum of Products = 626 − (Total No. of Variables × Mean Ration × Mean Yield) = 625 − 30 × 5.2 × 3.5 = 80.
The Sum of Products has been calculated in two ways in order to check the arithmetic.

$$\text{Correlation Coefficient} = \frac{80}{\sqrt{87.5 \times 198.8}} = .6 \text{ (as originally calculated.)}$$

The Estimation of the Correlation Coefficient, from a Frequency Table.—It has already been explained that in order to obtain an accurate measure of the correlation between two characters a large number of readings is essential. In consequence, with calculations involving several hundreds or thousands of variables, the amount of work concerned in calculating the correlation or regression coefficients by the method detailed previously is enormous. It is more usual with large samples to draw up a frequency table with the variables arranged in groups or classes. In order to illustrate the use of such a Frequency Table, let us assume that, in Example I, the milk yield had been measured in pints and the rations in quarter-pounds. The Correlation Table would then be as in Table III with the milk yields grouped in half-gallon classes, and the rations in lb. classes. The sums of squares have been estimated by the short method of squaring the variables and correcting, instead of using the deviations themselves: the procedure is otherwise self explanatory.

Discussion.—It has been thought easiest to explain regression in connection with correlation. Fisher points out that regression is of much wider significance, and can be applied to problems in which correlation would be of little value to the statistician. While the preceding examples explain in an elementary fashion how correlation and regression coefficients can be calculated, they do not provide an adequate explanation of the practical use of these in experimental work. The subject is too large to be dealt with in a short article. In consequence, the following note of warning is appended. Correlation is a two-edged weapon. Without a comprehensive grasp of all the interacting factors that require consideration in using it to interpret experimental results, it can lead to apparently striking but entirely wrong conclusions. Such false deductions in the past have brought it into a certain degree of unwarranted disrepute. On the other hand, in the hands of the expert, it has added greatly to scientific knowledge, particularly in regard to sociological and biological problems.

The Significance of the Difference between Means of Parallel Series.

It frequently happens in experimental work that two similar, but not identical series of readings are obtained from some particular factor under test. For example, parallel series of readings might be obtained for the size of spores from two separate cultures of a particular fungus, or for the annual yield of twenty selected apple trees over a number of years or for the number of flowers opening on similar strains of cotton in successive days. Consider the following figures for the count of ripe canes at harvest time on two selected sugar-cane stools during a five-year period. It is desired to ascertain from these data whether it can be assumed that there is any real difference between the ratooning capacity of the two stools. One method of proving this would be to work out the standard deviation for the records of each stool separately, then calculate the standard error of the difference between means, and use this standard error to test whether their difference is significant or not. This method of analysis is detailed in Example II.

EXAMPLE II.

Age of Stool in Years.	SERIES A.		SERIES B.	
	No. of Ripe Canes per Crop, Stool A.	Square of Variable.	No. of Ripe Canes per Crop, Stool B.	Square of Variable.
1	1	1	12	144
2	3	9	9	81
3	4	16	8	64
4	6	36	6	36
5	6	36	5	25
Totals ..	20	98	40	350
Means ..	4	..	8	..
Sums of Squares ..	S.S. Series A $= 98 - \frac{20^2}{5} = 18$		S.S. Series B $= 350 - \frac{40^2}{5} = 30$	
	$\sigma A = \sqrt{\frac{18}{4}}$ Standard Error of Mean of A $= \sqrt{\frac{18}{4 \times 5}} = .95$		$\sigma B = \sqrt{\frac{30}{4}}$ Standard Error of Mean of B $= \sqrt{\frac{30}{4 \times 5}} = 1.22$	

Standard Error of the Difference between Means $= \sqrt{.95^2 + 1.22^2} = 1.55$
The reading of t from Fisher's Tables for 4 Degrees of Freedom & P = .05, is 2.776.
Therefore, a Difference between Means greater than 1.55×2.776 or 4.30 is significant.

In Example II, the difference between means is only 4, and must be regarded as a non-significant one.

EXAMPLE III.

While this method of analysis is perfectly correct, it is effective only when applied to relatively large samples which provide an accurate measure of the standard deviation of each series and a value of t based on a correspondingly large number of degrees of freedom. In the case of small samples, it is better to base the estimate of the standard deviation on the combined data for the two series. To do this, the sums of squares, as calculated for each series separately, are added together and divided by the aggregate of the degrees of freedom, and the square root taken. If σ_{A+B} represents the standard deviation for the combined records in Example II, then

$$\sigma_{A+B} = \sqrt{\frac{18+30}{4+4}} = \sqrt{\frac{48}{8}} = \sqrt{6}$$

$$\text{The Standard Error of the Mean of 5 variables} = \sqrt{\frac{6}{5}}$$

$$\text{The Standard Error of the Difference between two such Means} = \sqrt{\frac{6\times 2}{5}} = 1.55$$

The standard error of the difference between means is exactly the same as that calculated in Example I. It is now based on eight degrees of freedom instead of four, and the reading of t for n = 8 and P = .05 is 2.306.

Therefore a difference greater than 2.306×1.55 or 3.57 is significant. The difference between means is the same as in Example I, namely 4, but it has now been shown to be significant as measured by a probability of .05. This slight alteration in the method of analysis has therefore been of undoubted advantage as applied to the above data.

It is possible to work out a value of t from the recorded data, and use this figure to estimate the probability of significance of any given difference between means. t by calculation is

$$\frac{\text{The Difference between Means}}{\text{The Standard Error of that Difference.}}$$

In Example III,

$$t \text{ by calculation} = \frac{4}{1.55} = 2.58$$

The number of degrees of freedom of the standard deviation from which this value of t was estimated, is 8. By reference to Fisher's Table of t for degrees of freedom or n equal to 8, it will be seen that the calculated value of t of 2.58 lies between the probabilities of .05 and .02, the readings for these values of P being 2.306 and 2.896. The chances that the difference between means is significant are therefore between 20 : 1 and 50 : 1.

In experimental work, it is by no means uncommon to have more than two parallel series; the number is often limited only by the number of counts which the research worker is prepared to take, each group of readings differing from the previous one in some minor particular. In such instances, the second method of estimating the standard deviation has obvious advantages as it will give an average figure for the standard deviation derived from all the records available. It will therefore approach more closely to the true value of σ for the whole population from which the random samples have been taken, and in addition, the estimate of t will be based on a much greater number of degrees of freedom.

EXAMPLE IV.

Let us assume that a third stool had been taken and a similar count made of the number of ripe canes on this stool over the same five-year period. The results are recorded in Example IV.

EXAMPLE IV.

Age of Stool in Years.	No. of Ripe Canes Stool C.	Square of Variable.
1	11	121
2	10	100
3	5	25
4	3	9
5	1	1
Totals	30	256
Means	6	

$$\text{Sum of Squares} = 256 - \frac{30^2}{5} = 76$$

$$\sigma = \sqrt{\frac{76}{4}} = 4.36$$

$$\text{The Standard Deviation for the combined results of the three Series, A, B \& C} = \sqrt{\frac{18+30+76}{12}} = \sqrt{10.3}$$

$$\text{The Standard Error of the Difference between Means of any two Series} = \sqrt{\frac{10.3}{5}} \times \sqrt{2} = 2.03$$

For 12 Degrees of Freedom and P=.05, the reading of t $= 2.179$

A difference between means of series greater than $2.03 \times 2.179 = 4.42$ is significant. The largest difference between means is that between Series A and B, namely four units, proving at once that the three series do not differ from one another as tested on a 20 : 1 chance basis. This reverses the conclusion arrived at in Example III, and is explained by the fact that the third random sample shows a much wider variation than either of the other two. As the result in Example IV is based on a larger number of random samples, it should presumably form a more valid estimate of the amount of dispersion in the population as a whole, and therefore must be regarded as the one most likely to be correct with the limited data available.

Where the standard deviation is computed from the combined data, it is possible and advisable to carry the analysis a stage further by calculating, in addition to σ, the variance due to the difference between series. The z test may than be applied to compare this variance with that already determined in the estimation of the standard deviation. A complete analysis of variance of the data in Example IV, might be calculated as follows :—

The sum total of variables in series A, = 20
do. do. do. B, = 40
do. do. do. C, = 30
Grand Total .... = 90

The total number of variables concerned .... = 15 (5 in each series).

Therefore the Sum of Squares between series

$$= \frac{20^2+40^2+30^2}{5} - \frac{90^2}{15} = 40$$

As there are three series, the number of degrees of freedom of this sum of squares is 2.

Analysis of Variance.

Due to	Sum of Squares.	Degrees of Freedom	Variance	$\frac{1}{2}$ Log$_e$ of Variance.	Calculated Value of z.
Between Series	40	2	20.0	1.4978	—
Within Series, *i.e.*, the combined S.S. for A, B & C or Error S.S. ..	124	12	10.3	1.1661	.3317
Total	164	14	—	—	—

The reading from the Table of z for $n_1 = 2$, $n_2 = 12$, and P = .05 is .6786. This is much greater than the calculated value of z, and demonstrates, without the necessity of working out the standard errors, that no significant difference exists between the means of the three series. The arithmetic can be checked by calculating the total sum of squares of all the actual data ; this is the sum of squares of all the individual variables minus the square of the grand total divided by the number of variables.

In the above example, the Total S.S. $= 704 - \frac{90^2}{15} = 164$ (as calculated above.)

This method of analysis has been discussed at some length as it applies to a very wide range of experimental results. Basal data relating to such divergent subject matter as soil moisture determinations, germination percentages, bacterial counts, protein analyses, rainfall distribution, fungal growth rates, weight increments, &c., will often lend themselves to this form of statistical treatment.

Direct Calculation of the Standard Error of the Difference between Means.—If Series B and C are compared, it will be seen that the variables in the two series resemble one another not only in being the number of ripe canes from a single stool, but also because they represent the number of canes for the same successive series of seasons and crops, namely plant cane, and 1st, 2nd, 3rd and 4th ratoons. The variables are arranged in the order of the crops one to five, and it is obvious that in seasons in which Series B has given a large number of canes, Series C has also been highly productive, and *vice versa*. This suggests an alternative method of analysis which uses this relationship in order to reduce the effects of sampling error to a minimum. The standard error of the difference between means can be calculated directly from the sum of squares of the differences between the corresponding pairs of variables.

EXAMPLE V.

Age of Stool.	No. of Canes Series B.	No. of Canes Series C.	Difference B – C for Corresponding Crops. +	Difference B – C for Corresponding Crops. –	Square of Difference.
1	12	11	1	—	1
2	9	10	—	1	1
3	8	5	3	—	9
4	6	3	3	—	9
5	5	1	4	—	16
Totals	40	30	+11	−1	36
			+10		
Means	8	6	+ 2		

S.S. of Corresponding Differences $= 36 - \frac{10^2}{5} = 16$

Standard Deviation of such Differences $= \sqrt{\frac{16}{4}}$

Standard Error of the Mean Difference $= \sqrt{\frac{16}{4 \times 5}} = .89$

The reading of t for four degrees of freedom and P=.05 is 2.776. A difference between means of series greater than .89 × 2.776 or 2.47 is significant. As the mean difference is only 2.0, this must still be regarded as non-significant. If, however, the method of analysis outlined in Example III had been applied to the above data the measure of significance becomes 5.30 instead of 2.47. The calculated values of t would be .87 and 2.25 respectively. Comparing these values with readings in the Table of t for their respective degrees of freedom (eight and four) it can be demonstrated that the direct method of calculating the standard error of the difference has increased the chances of significance from about 2 : 1 to 10 : 1.

This method of calculating the standard deviation directly from the differences is permissible only where a definite relationship between the corresponding pairs of variables exists. If the readings of Series B had been for different seasons and different crops than those of Series C, there would be no such affinity between corresponding variables in the two series, and in consequence this system of analysis would be invalidated. Moreover, advantage will only accrue if there is a marked positive correlation between the two series, *i.e.*, if high figures in the first series coincide with high figures in the second. Where the correlation is not great or where it is negative, the level of significance will be increased rather than decreased. This is partly due to the reduction in the number of degrees of freedom from which t is calculated, but also to the fact that where high readings in one series tend to correspond to low ones in the second, the sum of squares of differences will be unduly large. Comparison of Series A and Series C illustrates effectively the truth of these statements.

EXAMPLE VI.

Age of Stool in Years.	No. of Canes Series A.	No. of Canes Series C.	Difference C – A for Corresponding Crops.		Square of Difference.
			+	–	
1	1	11	10	—	100
2	3	10	7	—	49
3	4	5	1	—	1
4	6	3	..	3	9
5	6	1	..	5	25
			+18	– 8	
Totals	20	30	+10		184
Mean	4	6	+ 2		

S.S. of Differences $= 184 - \frac{10^2}{5} = 164$

Standard Error of the Mean Difference $= \frac{164}{4 \times 5} = .286$

t by calculation $= \frac{2}{2.86} = .70$

Probability of significance = 2 : 1 approximately.

If we analyse the same data by the method described in Example III,

The Sum of Squares = 76 + 18 = 94.

The Standard Error of the Mean Difference $\frac{94 \times 2}{8 \times 5} = 2.17$

t by calculation $= \frac{2}{2.17} = .92.$

Probability of significance = 3 : 1 approximately.

In this example, therefore, the standard error of the mean difference has been considerably increased by using the differences between parallel readings. Both methods are statistically correct. The research worker can therefore choose the one which, in his opinion, provides the most accurate interpretation of the data.

(*To be concluded.*)

REVIEW.

A SURVEY OF THE MARKETING OF FRUIT IN POONA. By D. R. Gadgil, M.A., M. Litt (Cantab.) and V. R. Gadgil, B.Ag. (Bom.), M.Sc. (Calif.) *Gokhale Institute of Politics and Economics*, Publication No. 3, pp. 184. Price Rs. 2-8.

The Royal Commission on Agriculture in India (1928) drew particular attention to the lack of systematic market surveys in that country, and this publication deals with the initial attempt of the Gokhale Institute to supply this deficiency. As usual, in such cases, too wide a field was originally selected, the combined problem of fruits and vegetables in the Poona District having to be reduced to that of fruit alone.

Even this provided ample scope when it is realized the many difficulties which confronted the authors. The diversity of the crops, the scattered nature of the producers' holdings, the entire lack of any statistics of local market prices and the attitude of suspicion exhibited by the majority of the commission salesmen in Poona, rendered this a truly herculean task. To overcome the latter difficulty alone, Mr. V. R. Gadgil himself attended the Reay Market in Poona for a number of days each week for over a year. In so far as such information goes, it is reasonably accurate and it illustrates the difficulties of such surveys when workers have to depend entirely on personal observations of actual transactions.

The questionnaire method of obtaining information from growers proved unsuccessful unless the investigator personally visited them and filled in the details on the spot.

The above will serve to show the amount of work involved in such researches and the authors deserve credit for their efforts which have brought to light many interesting facts.

A. W. P.

AGRICULTURAL NOTE BOOK.

Copies of Professor Wood's "Note-Book of Tropical Agriculture" (price 5 shillings) may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

THE PHENOMENON OF DECAY IN TIMBERS.*

During the period September to February, 1934, there have appeared in the "Journal of the Society of Chemical Industry" a series of articles on decay in timbers by Ernest A. Rudge of the Technical College, Cardiff who advances a new theory concerning the causes and initial stages of rotting. In the estimation of the author, decay is not primarily due to the attacks of biological organisms which secrete enzymes to break their way into the tissues but to infiltration of calcium ions, either alone or in conjunction with bicarbonate ions, to form chemical compounds with the cell materials, thereby resulting in loss of coherence and tenacity. In view of the fact that modern building practices, especially in the tropics tend so much to combine wood and concrete, and concrete contains calcium compounds, it may be useful to consider this new hypothesis.

The evidence commences with the case of a greenheart pile which had stood many years in a damp matrix of sea-shells and sand. The outer decayed tissues differed from the inner and sound tissues principally in the calcium content which was abnormally high in the outer tissues. A pitchpine pile which had been embedded in damp clay for 45 years showed no decay when lifted. The tissues contained much salt but no more than the usual amount of calcium. The embedding clay too was free from lime. A deal joist which had been set in a poor, porous concrete was also found to be much decayed and the calcium content of the tissues next the concrete was much higher than that of the inner tissues where the fibres were still sound. The concrete contained large amounts of calcium. The electrical resistance of greenheart with a moisture content of 20 per cent. is but a few hundred ohms, whilst properly dry with a moisture content of eight per cent., its resistance is of the order of several million ohms. These facts suggested that timber with a moisture content in the region of 20 per cent. offered no difficulty to penetration by inorganic ions such as calcium or bicarbonate and that one or both of these ions formed compounds with the cell materials resulting in general breakdown. Once the decay was initiated in this manner then biological organisms might enter easily and cause a very accelerated decomposition. Chemical analyses show that much 'cellulose' is removed during the initial processes of breakdown.

Thus the essential conditions for either wet rot or dry rot appear to be:—

(1) Unseasoned timber or timber with a moisture content of more than about 12 per cent. followed by

(2) The presence of free calcium or bicarbonate ions or possibly both.

Other examples which support this hypothesis are:—

(*a*) A deal skirting board backed with plaster and painted with lead paint on the outside which decayed on the inside and the analysis showed the calcium content of the tissues increased from the painted face inwards.

(*b*) A gatepost which, although embedded in concrete, decayed after two years. Here the stump was found to be sodden and with a high calcium content.

(*c*) A piece of pitchpine embedded in concrete and kept dry for 40 years showed no signs of decay.

(*d*) Shakes in telegraph poles were found to contain crystals of a calcium salt on the shake surface and a high percentage of calcium in the tissues near the shake, but practically no calcium in the tissues remote from the shakes.

In these cases there were no obvious signs of the presence of biological organisms but nevertheless the author does not prove conclusively that they were absent. Such fungi as '*Merulius lachrymans*' are known to secrete cellulose destroying enzymes and the calcium content of decayed timber may represent subsequent infiltration after biological attack. Although the hypothesis cannot be considered proven yet it is interesting in the light of our knowledge of cell structure. Decay in timbers resembles a condition reached by chemical maceration and it has been shown that this process dissolves out the 'middle lamella' separating adjacent cells, thereby freeing them. Now in cases where it has been demonstrated, the 'middle lamella' is supposed to consist of a *calcium* compound of certain pectic acids. This should be decomposed into soluble compounds by the action of bicarbonate ions.

Whether the actual initiation of decay is chemical or biological, it is very important in the humid tropics that timber placed in direct contact with concrete should be well seasoned and thoroughly coated with some material to render it impervious to water.

F. J. P.

* See also March issue, p. 75.

REPLACEMENT OF A BUD BY ROOTS.

Mr. Samuel Sandison writes from the Department of Botany, University College, Dundee, to report a striking case noted during some observations upon the propagation of *Forsythia suspensa* by cuttings. Usually roots arise from buds at the basal end of the cuttings and always from the basal half of the bud. In this case, when the bud scales were stripped off, the bud-apex had disappeared and in its place five roots were seen arising from a common point of origin, somewhere about the original base of the bud.—(*Nature*, Vol. CXXXIII, No. 3363).

NOTES ON COVER CROPS IN DOMINICA.

By F. G. Harcourt,
(*Agricultural Superintendent, Dominica.*)

Tephrosia candida.—This species, which is fairly widely used in citrus fields throughout Dominica, has an upright habit of growth, and reaches a height of about eight feet. It tends to branch freely, the branches becoming semi-woody. It bears an abundance of rather conspicuous white flowers. The seeds, which are produced freely, are ready for harvesting in November.

It is often sown irregularly between the citrus trees, and when closely planted is effective in controlling weeds. *Tephrosia candida* stands cutting back fairly well, and if this is done before the branches become old and woody, a fair quantity of useful mulching material may be obtained. Being fairly long-lived and deep-rooted, it is suitable for use as a temporary windbreak, and with this object primarily in view it has, on several estates, been planted in single or double lines, between the rows of citrus trees.

Tephrosia candida grows slowly in its early stages, and it is therefore necessary to prepare the land before sowing in order to hasten growth as much as possible. Two weedings are usually required before the plants shade the ground sufficiently to control weed growth.

At the Government Fruit Farm, Copt Hall, a five acre citrus plot was planted with this cover crop. The citrus trees are planted 30 × 30 feet apart, and two rows of *Tephrosia* were planted alternately with the rows of citrus trees. The calculated cost per acre of establishing the cover crop was as follows :—

	s.	d.	£	s.	d.
Preparation of the ground and planting :					
2½ man days at 1*s*. 4*d*.	3	4			
1 woman day at 10*d*.		10			
				4	2
Weeding (twice) :					
22 woman days at 10*d*.	18	4		18	4
			£1	2	6

Canavalia ensiformis (Horse Bean or Sword Bean).—The horse bean is popular as a short term cover crop in Dominica. When grown in the open it is of more or less erect habit, and although tending to climb when in shade if support is available, the climbing stems rarely become numerous or heavy enough to interfere seriously with the growth of citrus or other orchard crop plants. It grows quickly during its early stages, except during very dry weather. The large dark green leaves throw a fairly dense shade so that it quickly becomes effective in checking the growth of weeds, and is especially useful where a cover crop is required for a short period only. If allowed to seed the horse bean dies down about eight to ten months after sowing, but its growing season may be prolonged for several weeks by cutting the plant back to ten inches from the ground when the young seed pods are about two inches long. It may be dug into the ground as a green manure, but the weight of material it provides for this purpose is not great.

In planting this crop on land which has been recently forked the seeds may be sown broadcast. Where there has been no preparation of the ground, other than cutlassing, the usual method is to make small holes about a foot apart and to place two seeds in each. The cost of planting one acre by the latter method, at the Government Fruit Farm, Copt Hall, worked out as follows :—

9 woman days at 10*d*. .... 7*s*. 6*d*.

Crotalaria spp.—Many species of Crotalaria have, at various times, been tried by the Agricultural Department, the three most successful at present in use being *C. spectabilis*, *C. striata** and *C. oocarpa*. The first two are of erect habit and grow to a height of about five feet. The seeds germinate soon after being sown and the young plants grow quickly. Under favourable conditions, an effective cover crop is formed and lasts for a period of about six months. Both species produce a large amount of green material suitable for use as green manure or mulch.

C. oocarpa has a decumbent habit, and grows about three feet high, forming a matted growth. This plant is also a quick grower in its early stages and is effective in controlling weeds. It may be propagated readily by seed, which is produced freely.

Indigofera endecaphylla.—This plant was introduced into Dominica a few years ago, and seems likely to prove a very valuable permanent cover crop. It is of sub-erect or prostrate habit, and the older creeping stems become woody, and from nearly every node roots are produced which bear nodules in considerable numbers. Although the plants flower freely and pods are formed, seed has never been observed to ripen in Dominica, and propagation is effected by cuttings. At first the growths lie flat on the ground, but two or three months after the rooting of the cuttings, the stems begin to grow upwards, and form a dense mat fifteen inches deep. In plots where this cover has been established for a year or more, a layer of partly decomposed stems and leaves is formed

* The plant under discussion has been named *C. striata* only provisionally, as it differs from *C. striata* as known in Trinidad in several minor morphological characters, and whether the differences are specific or varietal has not yet been determined.

beneath the living portions of the plant. *I. endecaphylla* is such a recent introduction in Dominica that it is not possible to give any definite information as to its permanence, but two small plots established by the Agricultural Department three years ago show no signs of deterioration. These have been cutlassed twice and gave a useful quantity of mulching material.

I. endecaphylla has been planted on steeply sloping land, and has proved very effective in preventing soil washing. Its suitability as a cover among bearing lime trees is doubted, as fruit falling among its dense growth is difficult to collect.

The method of planting adopted by the Department is to use cuttings of half-ripened stems. These are made nine inches long, and are planted in small bunches in holes a foot apart. Three weedings have been found necessary during the early stages of growth, making the cost of establishing this cover comparatively high.

The cost per acre calculated from figures for a small plot at Copt Hall is as follows :—

	s.	d.	£	s.	d.
Planting cuttings :					
9½ man days at 1s. 4d.	12	8			
3 woman days at 10d.	2	6		15	2
Weeding (three times) :					
58 woman days at 10d.			2	8	4
			£3	3	6

Cajanus indicus (Pigeon Pea).—This legume is widely grown in citrus plantings, in Dominica, primarily as a catch crop. It is of some value as a cover and as a temporary windbreak. The variety mostly used grows to a height of eight feet, producing woody stems, and may be cut back to about two feet from the ground, the loppings providing a fair quantity of mulching material. In planting, the seeds may be sown broadcast or in patches, and at least one weeding is required before the young plants become established. The lower branches are so far from the ground and the foliage is so light that it is seldom effective in controlling weeds. The pigeon pea is of undoubted value as a catch crop, but as a cover crop *Tephrosia candida* is considered superior.

CACAO NOTES.

The Cultivation of Cacao in the Temperate Zone.

The *Gordian* for January, 1934, publishes an abstract of a book on Cacao written by Mr. W. P. Malejew, who is a scientific specialist of the All-Russian Botanical Institute.

The aim of the book is to promote research in growing *Theobroma Cacao* in Soviet Russia. The author states that the chocolate industry in Russia is very little developed, only four to five thousand tons of beans being consumed annually. The principal reason given is that all the raw products have to be imported from abroad. Two suggestions are advanced to increase the consumption of such a valuable calorific food as cocoa : (*a*) to produce cacao butter, theobromine and other essentials of the cacao bean by synthetic means, (*b*) to grow the bean in Russia itself. The first suggestion is already under way and is likely to lead to a commercially exploitable result. For the second suggestion the author notes that cacao trees have been grown successfully in York, Heidelberg, Munich and Leningrad in hot houses, that they set a few fruit only, although they flower well, but that with artificial pollination they mature and ripen many good pods. The trees suffer most during the short days of winter when they tend to defoliate, but with artificially increased day period this does not happen.

The idea advanced is that Forastero trees might be grown successfully in Southern Russia in large heated sheds which could be covered and supplied with artificial light in the winter months. Already the Soviet Government has voted funds for the research and 200 trees have been put into hot beds for future transplanting.

F. J. P.

* * *

A Note on 'Productive Efficiency' in Cacao.

In the third Annual Report for Cacao Research prepared at the end of 1933 the concept of 'productive efficiency' was brought forward in relation to cacao tree yields. In that report it was explained how the efficiency of any particular type of cacao tree was governed largely by climate and other environmental factors, such that 'between countries, totally different genotypes may be necessary for success in cacao cultivation, and even within one country there is much to be done in the fitting of different genotypes to different localities before maximum efficiency can be secured all round.' Generally the aim should be to grow the largest beaned type which will thrive in the particular locality since large beans make for quality of produce and yield efficiency. It is interesting to note that in the *Gold Coast Farmer* for April, 1934, it is stated that in some districts of Ashanti there are a number of farmers who grow a large beaned type of the variety Cundeamor, the trees of which are larger and more robust than the Forastero trees commonly grown. This suggests that in the more favourable districts of West Africa the Cundeamor type may be more efficient than the Amelonado, a point which is being investigated without delay since the beans average 9.5 mm. in thickness as against 7.5 mm. for Amelonado and buyers are giving a premium for them.

F. J. P.

COVER CROPS IN DOMINICA.

FIG. 1.—*"Indigofera endecaphylla", with "Tephrosia candida" as a light windbreak, on sloping land. Lime Experiment Station*

FIG. 2.—*"Indigofera endecaphylla", among recently planted citrus.*

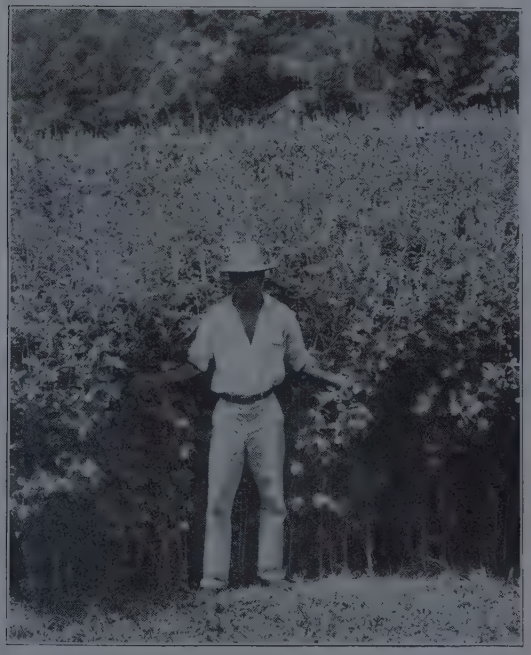

FIG. 3.—*"Crotalaria striata."*

FIG. 4.—*"Crotalaria striata", with "Gliricidia maculata" as a light windbreak.*

COVER CROPS IN DOMINICA.

FIG. 5.—*"Canavalia ensiformis" (Horse bean) among newly planted citrus trees.*

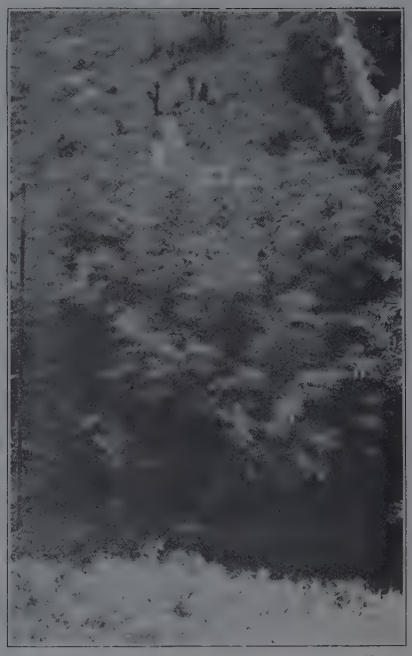

FIG. 6.—*"Tephrosia candida" as a light windbreak.*

FIG. 7.—*"Crotalaria spectabilis" in citrus plot.*

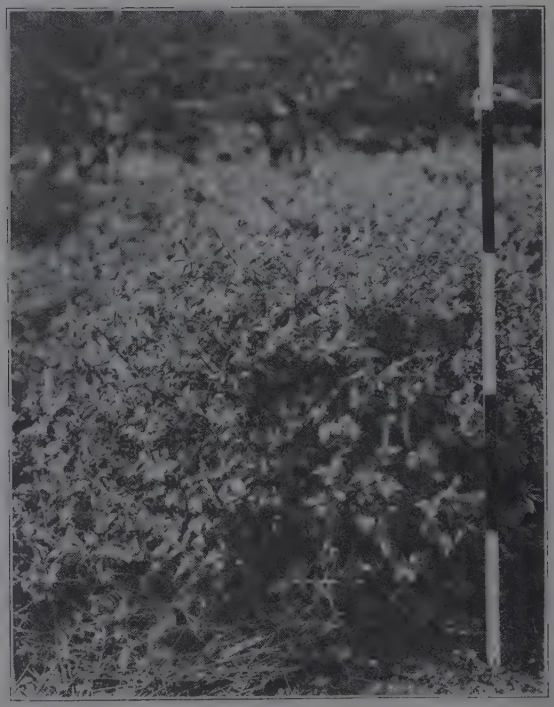

FIG. 8.—*"Crotalaria oocarpa." Botanic Gardens.*

BANANA DISEASES.

IX.—The Occurrence of Sigatoka Disease on Bananas in Trinidad.

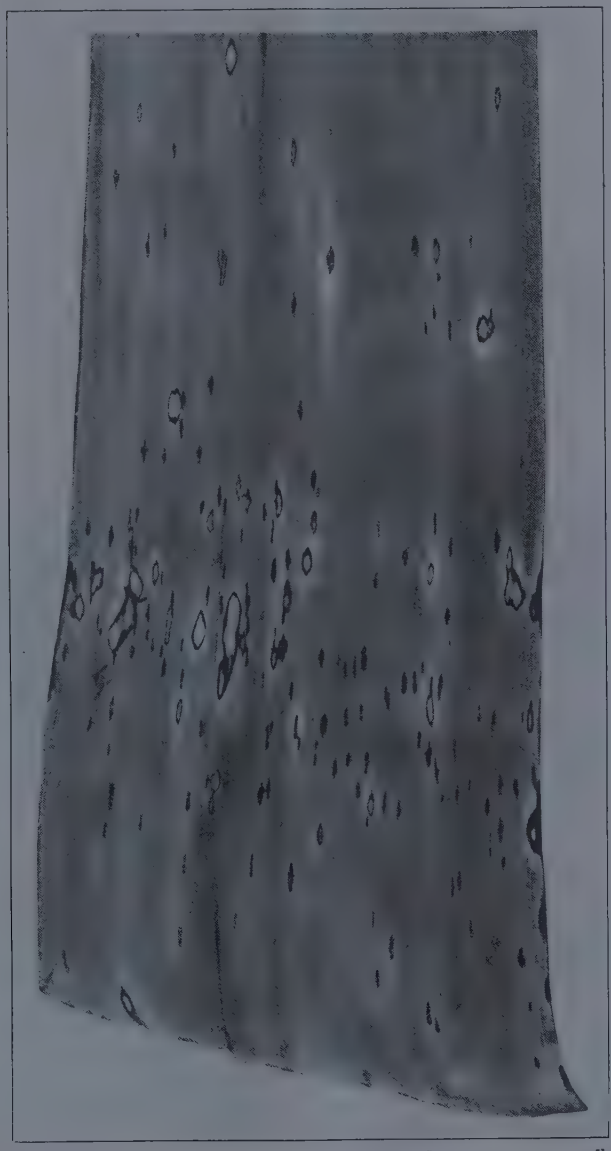

FIG. 1.—*Profuse spotting caused by "Cercospora musae" Zimm. on a leaf of the Giant Governor variety.*

BANANA DISEASES.

IX.—The Occurrence of Sigatoka Disease on Bananas in Trinidad.

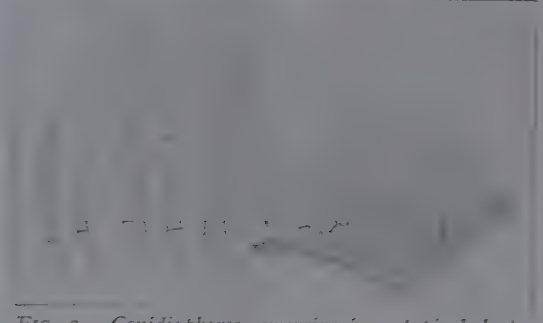

FIG. 2.—*Conidiophores, emerging in a typical cluster through the upper [illegible] and conidia of "Cer[illegible]" Z[illegible].*

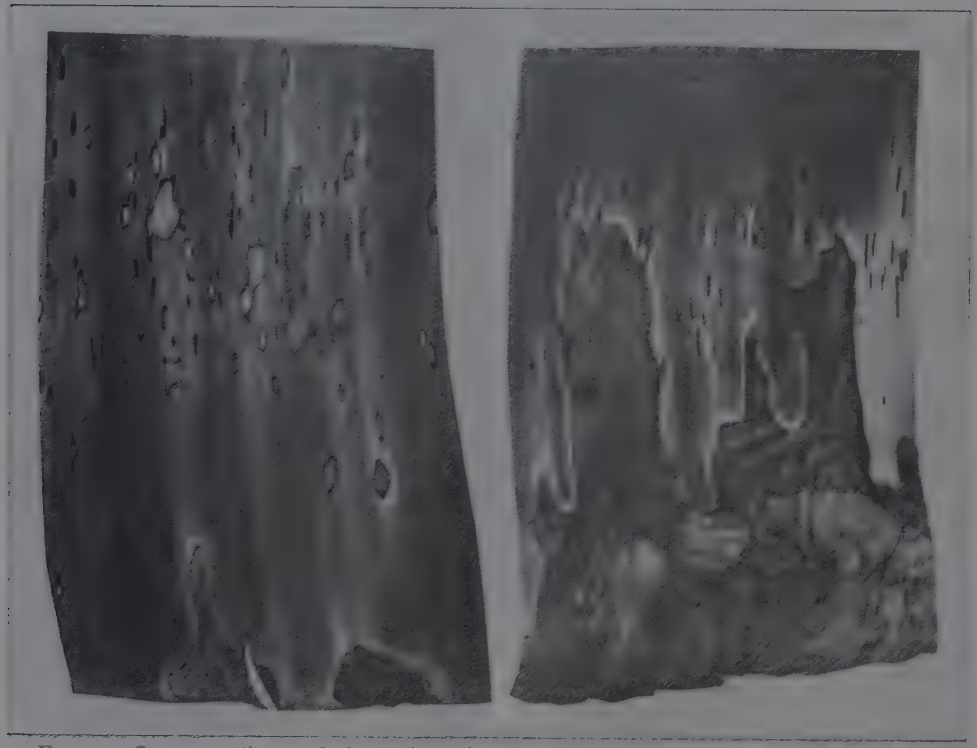

FIG. 3.—*Severe spotting and destruction of considerable areas of leaf tissue caused by "Cercospora musae" Zimm.*

BANANA DISEASES.

IX.—The Occurrence of Sigatoka Disease (*Cercospora musae* Zimm.) on Bananas in Trinidad.

By C. W. Wardlaw.

Occurrence.

Though fairly widely distributed in the Indo-Malayan and Australian regions, the leaf spot of bananas caused by *Cercospora musae* Zimm. (*C. musae* Massee) has not hitherto been recorded in the Western Tropics. Recently, however, whilst examining bananas in the Maqueripe district, the writer observed a characteristic spotting on the leaves of the Governor (Dwarf Cavendish) and Giant Governor varieties. On examination this proved to be the *Cercospora* leaf spot of Australia (now known to be identical with the so-called Sigatoka Disease of Fiji (5, 6)), a diagnosis which has been confirmed by the Imperial Mycological Institute, Kew, from specimens submitted. In addition to the two varieties mentioned above, the disease has also been observed on the Gros Michel and Bande varieties in the same locality.

In Queensland the Gros Michel and Cavendish varieties are outstanding in their susceptibility to this disease. The Mons Marie, a tall Cavendish mutant probably closely akin to the Giant Governor, is also very subject to attack (12).

This disease is quite distinct from the common marginal and oval leaf spots caused by *Leptosphaeria musae* Zimm. Helm. (4).

Importance.

While *Cercospora* leaf spot is unimportant in most countries, it has become epidemic in Fiji and Queensland, presumably in relation to continued close cultivation, growth conditions, environmental factors favourable to the pathogen and the variety of banana chiefly cultivated. The disease was originally recorded in Java in 1902 by Zimmermann (13), and by Massee in Fiji in 1914 (8). It is also known in Ceylon (1) but, as in Java, it is of minor importance.

In Fiji, the disease appeared in 1913 on Gros Michel bananas in the Sigatoka district (after which it is sometimes named) and subsequently spread to other districts. All commercial varieties seem to be susceptible. The fungus has been observed on Sawaka (*Musa fei*), it attacks the Cavendish and China Vimama varieties seriously, while the Gros Michel is said to have been practically eliminated by it (4). In Queensland an active outbreak of the disease first caused alarm in 1925 (3); it is thought that a slight leaf spotting had probably been occasionally recognised by planters as early as 1920 and 1922. The disease now extends over a wide area and in some districts is reported as serious. After an extensive tour of the banana districts of Southern Queensland in 1928 Dickson (7, 8) reported that in the majority of plantations leaf spot was prevalent. In most cases it was causing serious loss, and a marked reduction in yield was anticipated. It was not uncommon to find plantations where but few of the bunches formed would fill out and mature because of the complete dying of the foliage. In Queensland this disease is of such importance that it is the subject of special official investigation.

In Trinidad the disease has so far only been observed on one area, but the intensity of spotting both on the Dwarf Cavendish and Giant Governor varieties and the destruction of leaf tissue which ensues are sufficient indications that this outbreak should not be neglected.

Symptoms.

The first indication of infection is the appearance of light brownish-green, indistinct linear markings, $\frac{1}{8}$ to $\frac{3}{8}$ inch in length, lying parallel to the veins. These spots increase slightly in size and dry out slightly, forming dark muddy brown to black, linear-oblong or eliptic areas up to $\frac{1}{2}$ inch in length and about one-third of this in width. On the lower leaves of young plants larger and broader spots are present; they show as dark brown, oval to almost circular areas up to $\frac{1}{2}$ inch in diameter. In time the centre becomes a dirty white or greyish colour, and is surrounded by a narrow, well-defined dark brown margin. Between the latter and the normal dark green of the leaf there is frequently a bright yellow-coloured transitional zone, Fig. 1. The grey spots can usually be distinguished even after the leaf has completely withered. On the upper surface of the white centres, numerous black specks are present on which the conidia of *Cercospora musae* are borne, Fig. 2. At the time of sporulation, the surface of the spot has a powdery, slightly greenish appearance.

When the spots remain small little damage is done. More frequently, however, the tissue round the spots begins to die rapidly and large, coalescing, dead patches are formed so that the leaf is more or less completely destroyed, Fig. 3. It is this rapid destruction which makes the disease so serious.

In all of the aforementioned characters the disease in Trinidad is identical with that observed in the East. In the area under observation, the most severely affected plants had the three or four lower leaves badly spotted, the leaf-blades being extensively destroyed later by the drying out of large areas, Fig. 3. The more serious symptoms recorded in the East, namely, rotting and breaking down of the petiole and midrib by secondary fungi and bacteria, more or less complete destruction of the foliage, failure of immature bunches to ripen and so on, were not observed during the current investigation.

By way of indicating the destructiveness of this disease in really severe outbreaks in the East, the following points may be mentioned.

The destruction of foliage—an outstanding feature of the disease—was the subject of comment by Philpott and Knowles (10) during their preliminary investigation in Sigatoka in 1913 : " A feature of the plot which struck us at once was the comparatively small number of leaves on the older plants and a short walk through the plantation enabled one to observe plants with any number of leaves from five to none . . . Many plants were seen which had not more than three green leaves and others had only two, some only one and some none at all. Finally stalks were seen from which the bunch had fallen and possessing no leaves. This seems to be the last stage. Bunches which had fallen in this way were examined and it was found that the stalk had decayed at about the place where it emerges from the crown of the plant. The bananas were green and angular, being about half " full " or less and when broken across, the pulp had the characteristic yellow appearance of nearly mature fruit".

The effect on the fruit is indirect, depending on its state of development and the severity of the attack. Immature bunches fail to ripen. In bunches which are almost mature the flesh ripens, but externally the fingers remain undersized and more or less angular. Although the flavour of the fruit is normal, its small size tends to make it unmarketable. In Queensland, loss due to failure to mature is not uncommon in fruit which normally would be cut during the winter and early spring months.

Inoculations require about four months before definite lesions are produced. Both sides of the leaf appear to be equally susceptible. Artificial infections have only given positive results when the conidia were sprayed on to the leaf surface, natural atmospheric humidity alone being apparently insufficient for germination.

The Fungus.

Cercospora musae Zimm., the fungus causing leaf spot disease in Queensland and Sigatoka disease in Fiji, was first described from material collected at Buitenzorg, Java, by Zimmermann in 1902 (14) and 12 years later in Fiji by Massee (9) who was unaware of Zimmermann's record. The organism originally described by Ashby (2) in Jamaica as *Cercospora musarum* is a different fungus and is now known as *Helminthosporium torulosum* (Syd.) Ashby.

Conidium formation commences soon after the spots have assumed the dark brown colouration, but the presence of the darkish conidial clusters only becomes easily detected when the central region of the spots has dried out and become lighter in colour. Conidia may be formed on both sides of the leaf but are usually more abundant on the upper surface. They are narrow, elongated and multiseptate, being formed on the ends of dusky, brown, upright hyphae which project in clusters from the leaf surface, Fig. 2.

The conidial measurements and septation of the Trinidad strain (33-75μ × 2.5-5μ (commonly 3-4μ) and 0-3 septa) are in close agreement with those recorded by other observers from material obtained in Java, Fiji, Queensland and Malaya (*see* Simmonds (12)).

Effect of Climate, Season and External Factors.

In Queensland, leaf spot is of purely seasonal occurrence (11), the disease becoming increasingly prevalent until the end of winter, but disappearing with the resumption of growth in spring. A similar seasonal distribution also obtains in Fiji. The climatological factors involved are humidity and temperature, the disease reaching its greatest activity during the period of minimum temperature and maximum humidity

Dickson (7, 8) considers that *C. musae* is not a strong parasite, and therefore, in order to affect plants seriously, growth conditions must be such as to make for weakness and general debility. " Cold, wet weather, unsuitable situation, poorly drained soil, and poor cultural practices give a set of circumstances definitely favourable to the fungus and enabling it to assume epidemic proportions."

Both in Queensland and Fiji the investigations have been complicated by the activity and widespread distribution of the weevil-borer. While severe attacks of leaf spot are sometimes associated with weevil-borer infestations, further data are required before a direct causal relationship between them could be regarded as definitely established. In both countries there are many instances where the prevalence of leaf spot is associated with ill-drained and unsuitable soils; there, poorly developed and decayed root systems are the rule, and weevil-borer is much in evidence. In short, it seems evident that the lowered vitality and relative dormancy induced in plants during the cool weather is conducive to attack. On the other hand, during periods of rapid growth, the development of new leaves keeps pace with the spread of the disease and complete defoliation may not overtake the plant until the fruit is approaching maturity.

The factors operative in promoting severe infections under Trinidad conditions have not yet been ascertained. In the particular area under consideration, where the soil is a light sandy loam, exposure and drought factors may perhaps prove important.

Control Measures.

So far no precise control measures have yet been worked out. Dusting and spraying with fungicides in Queensland did not meet with the desired measure of success. The merits of systematic stripping as a means of reducing the severity of an attack are at present under consideration.

Suggestions advanced by Simmonds for controlling the disease include the following :—selection of the most favourable sites suited to the vigorous growth of bananas throughout the year; good cultivation and, where possible, manuring, should be practised towards the same end; wider planting, within economic limits, should be adopted to reduce humidity and lessen the rapid spread of the disease from plant to plant; since the conidia, abundantly produced on the lower leaves, are blown or splashed on to the healthy leaves above, subsequently causing infection, plantations should be inspected frequently and all the affected leaves carefully removed and destroyed by burning or burying; by this procedure it should be possible to reduce the amount of infectious material sufficiently to tide plants over their susceptible period without extensive damage being sustained; the removal of leaves should be carried out while the spots are still in the light brown stage, *i.e.*, before active sporulation has commenced; such sanitary measures should receive special attention during the first half of the year when the fungus is on the increase. Suggestions put forward by Campbell include the eradication of all abandoned and non-commercial plantations and patches of bananas, the prohibition of the transport of banana leaves as packing material, exclusion by quarantine of all banana material from areas or islands where the disease has not appeared, and rotation of crops to permit of a rest from bananas for a period of five years or so.

Treatment in Trinidad.

The area infected in Trinidad so far appears to be localised. Steps have accordingly been taken to destroy by burning all banana leaf debris on the plantation floor and to strip and burn all infected leaves, these operations to be repeated as required.

To Mr. S. F. Ashby of the Imperial Mycological Institute, the writer's thanks are due for his co-operation in this work.

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THE DAMAGE CAUSED BY ANTS IN SEED BEDS AND GARDEN AND HOW TO CONTROL THE PEST.

The following methods for the destruction of ants and their nests are recommended by the author, Mr. W. H. Edwards, Government Entomologist in Jamaica, as being simple and effective. In situations devoid of plants boiling water may be poured into the nest, or a solution of cyanide of potassium 1 oz., water 1 gal. An effective formula harmless to plant life is hard soap 75 gms., kerosene 1 litre, water ½ litre, creoline, crude carbolic acid or Jeyes' Fluid ¾ litre. The soap is first dissolved in boiling water, the kerosene is then gradually added and the mixture stirred till emulsified. The creoline or substitute is added and well mixed. The stock emulsion thus formed will keep indefinitely and is used at the rate of 1 part to 50 of water on lawns or strong plants and 1 part to 100 of water on seed beds. When applying any liquid insecticide to a nest the liquid should be first poured round the periphery of the nest until the ground is soaked in order to block the exits. The centre of the nest can then be treated. Destruction of nests by fumigation can be effected with carbon bisulphide placed in holes round the nest, 1 tablespoonful per hole, and then covered. The holes should be 8-12 inches deep and the same distance apart; or instead half a teaspoonful of calcium cyanide can be used per hole in the same manner. A long lasting non-poisonous repellant for painting posts supporting seed boxes is made by dissolving 2 lb. rosin in 2 litres of boiling castor oil and raw linseed oil mixed in equal parts. After boiling, air is blown through the liquid to cool it to atmospheric temperature and it is then painted on the posts in bands 3-4 inches wide.—(*Imperial Agricultural Bureaux, Hort. Abs.*, Vol. III, No. 3, Ab. 383.)

PRINCIPLES OF BANANA BREEDING.—*Continued.*

By E. E. Cheesman, M.Sc., A.R.C.S.,
Professor of Botany in the Imperial College of Tropical Agriculture.

Varietal Studies and Results.

The Imperial College banana collection at the end of 1932 had received in all 88 accessions of edible bananas, beside the fertile *Musa* species already mentioned. It was recognized much earlier in the work that many of the accessions were duplicates, and comparative studies have always had a place in the programme. Owing to the practical difficulties connected with smallness of area and poverty of soil available, progress with critical comparisons was slow in the earlier years, but towards the end of the period a substantial reduction of the number of labels in use became possible. One important result was that sets of breeding figures, formerly kept distinct, could be amalgamated when the clones to which they referred were proved identical. The evidence concerning the genetic behaviour of certain clones was thus strengthened to a degree permitting very definite conclusions to be drawn, and this was one of the factors leading to a revision of programme.

The procedure of comparison, now standardised, is that a new introduction is planted on receipt in a small observation plot where it is allowed to fruit. It may prove obviously different from anything previously studied, in which case it is added forthwith to the standard collection. If it resembles one or other of the established clones sufficiently to justify further comparison, a special "comparison plot" is laid out. In this not less than three stools of the introduction are planted alternately (at 12 ft. spacing) with an equal number of stools of the standard variety it is supposed to resemble. Care has to be exercised in choosing comparable planting material from both stocks, since suckers of different ages or degrees of vigour may give stools of rather different behaviour, especially with respect to earliness of fruiting. The pairs are kept under almost daily observation from planting to the harvesting of the fruit and watch is kept for the slightest difference of habit or behaviour at every stage. If planting has been right the pairs usually flower and fruit almost simultaneously, so that material for fair comparison is always available. If no difference can be detected, the comparison plot is still kept up until confirmatory evidence is available from chromosome numbers, breeding behaviour, and in cases where they are desirable cool storage trials of the fruit. Such a trial usually runs for at least two or three years before identity is formally admitted, though it may be assumed for working purposes after the first year.

It sometimes happens that an accession resembles an existing standard in every point of form and behaviour save one. In such cases the single difference has always proved to be of a kind judged as inessential from the genetical standpoint, and this kind of variation is most probably to be ascribed to somatic mutation. A notable case is that of the so-called "Green Red" banana, which resembles the common red-fruited type in every respect except pigmentation of the vegetative parts and of the fruit. This particular mutation is well known, and has occurred more than once in our variety plots. In another case one accession differs from another in nothing but the possession of a thicker wax bloom on the fruit, but the feature is constant from one vegetative generation to another. The practice in all these cases is to retain the variant as a *sub-type* of the standard.

As a rule when identity is finally established the accession is discarded to economise space and upkeep, but in occasional and particularly important cases it is desirable to retain duplicate stocks in order to preserve the evidence upon which identification has been based, and which would be expensive to re-assemble should any future doubt arise.

Working on these principles the 88 labels which at one time or another have been in use were reduced by the end of 1932 to fifty, made up of:

Clones recognized as distinct and used as standards	25
Sub-types and duplicates	5
Still under comparison with standards	17
Still under preliminary observation	3
	50

Of the 20 still under comparison or preliminary observation, the majority are recent accessions which have not formally passed all the criteria of identification, but are already accepted for working purposes as duplicates. Probably not more than three will ultimately reach the standard list as distinct varieties, so that the number of true varieties is less than thirty, that is one-third the number of accessions.

Illustrated descriptions of the 25 standard varieties are in course of preparation for publication elsewhere, and all discarded synonyms will be reported and discussed in the appropriate places. Details of the varieties in the present article would occupy too much space, and cannot be presented.

The collection of varieties in its reduced condition appears by comparison with the number of varietal names in the literature almost absurdly small. It must however be borne in mind that a relatively large number of countries have contributed to it, and there is reason to suppose that even now it contains a substantial proportion of the important varieties of the East. Perhaps one of the most significant results of the comparative studies has been the frequency with which recent collections in the Eastern Tropics have been positively identified with varieties already in the West Indies. Between 1898 and 1902 some 28 banana varieties from the East were sent from Kew to Dominica, presumably as one result of the

interest in bananas at that time which led to the extensive survey of the genus *Musa* in the *Kew Bulletin* of 1894. These bananas were propagated by the late Mr. Joseph Jones, then Curator of the Botanic Station in Dominica and subsequently distributed to the other Colonies in the region. The survivors in 1922 formed the nucleus of the Imperial College collection when the present work was started. Some were probably lost entirely in the 20 years between or discarded as synonymous with local varieties. Some have retained names from the original list, though where they have passed through many hands they cannot be safely taken as true to label, others have acquired new local names. Nevertheless several have proved indubitably identical with fresh introductions (under totally different names) collected in the East by F. N. Howes in 1928. Thus it appears that the Eastern varieties, which in 1928 were judged of probable interest for further study, were substantially the same as those judged worthy of study in 1898, although they carried different names and were probably collected in different countries. This supports the conclusion of the last section, that the profusion of varieties in the East has been exaggerated, and that the varieties of any considerable economic importance, at least, are strictly limited.

Polyploidy in relation to Breeding.

Since the final product of a banana breeding programme must be a sterile plant, some knowledge of the genetical basis of sterility in the group is a necessity, and it has always seemed likely that such knowledge could best be obtained from cytological investigations. It is now believed that the most important basic reason for sterility in bananas has been discovered, and that it lies in the fact that the majority of edible varieties are triploid plants.

Chromosome numbers have been counted in the somatic cells of eight fertile *Eumusa* species and varieties and 21 sterile clones, as well as a large number of seedlings raised in the course of breeding. In the great majority of cases the count is some multiple of eleven, indicating that eleven is the basic haploid number of the banana series.

All the fully seeded forms examined have $2n=22$, and are thus to be regarded as diploid. Among the sterile clones four are likewise diploid, and it is interesting to note that these are the four varieties in the collection with the slenderest pseudostems and that three of them at least approximate in habit to the wild *Eumusa* species. The remaining 17 have $2n=33$, and their sterility is readily understandable from what is known of the behaviour of triploid plants in general. It will be shown in the next section that counts of seedlings all support the same hypothesis. The most promising seedlings are tetraploid ($2n=44$) and in accordance with what might be expected as a consequence they exhibit greater fertility than their triploid parents.

From these data the bare outlines of a possible breeding plan begin to emerge. From analogy with existing varieties the probability is that the most successful product of breeding operations will be a triploid. The most common first result of crossing is a tetraploid. If the triploid condition can be restored at will, it may pay the breeder to work through any necessary intervening steps with tetraploids, using their greater fertility as a means of raising larger progenies than are possible from triploids, and to restore the triploid condition as the last operation. Experiment shows that in some cases the triploid condition can be restored by crossing a tetraploid with a diploid, and there for the time being knowledge rests. Triploids so raised have not yet proved practically useful, probably only because the right combinations have not yet been found.

Meanwhile the tetraploids themselves are not necessarily useless from the direct point of view. Their fertility varies, and at least one under observation seems to be self-sterile though cross-fertile. A self-sterile clone, if otherwise suitable, is all that is needed for commercial planting, and it may be that a tetraploid seedling will solve the economic problem.

In a later section attention will be given to an alternative method of breeding which appears at least theoretically sound, namely the synthesis of polyploids by intercrossing of fertile diploids alone, but the data available in that connection are more scanty.

Much, of course, remains to be done in filling in details on the plan outlined above. In particular the differing genetic behaviour of different triploids needs fuller investigation, for it already appears that not all the triploid clones are of similar constitution.

Results of Pollinations.

From September 1927 to the end of January 1932, when the first series was closed, the total number of pollinations made was 2,463. The unit in pollination is the whole inflorescence, which may contain almost any number of flowers up to 200. As a very rough approximation the average number of stigmas represented by each pollination recorded may be taken as about 100. A number of bunches were lost in development or discarded for one reason or another, and the number harvested and searched for seeds was 1,735. Of these 687 were reported in 1931 (14) but the figures have been incorporated here with the additional data from the other 1,048.

For the sake of simplifying the presentation of the data, the pollinations may be regarded as representing four lines of investigation, as follows:

1. Attempts to breed a disease-resistant banana from Gros Michel. Apart from its susceptibility to Panama Disease the characters of Gros Michel are desirable, and the aim might be described as the "building in" of resistance with the minimum disturbance of the genotype. Results are reported as "Breeding from Gros Michel".

2. Attempts to breed a suitable banana from varieties already possessing the required resistance in association with many of the good qualities of Gros Michel, but inferior to that clone in their reaction to the conditions of bulk transport. The varieties comprising the Cavendish group answer to the description, and results are reported as "Attempts to breed from the Cavendish group".

3. Investigation of the breeding behaviour of all edible bananas available, irrespective of their immediate commercial value, for the sake of general information. Results are reported as "Breeding from Minor Varieties".

4. Investigation of the results of crossing fertile species of *Musa*, also undertaken for the sake of general information which might guide the more directly economic lines. Results are reported and discussed in a separate section (Breeding by Species Crossing).

1. Breeding from Gros Michel.

The results to be discussed under this heading are as follows:

Table 1.

Cross.	Bunches cut.	Seeds found.	Germinations.
i Gros Michel × M. acuminata ..	58	50	14
ii Gros Michel × M. sapientum ..	5	nil	—
iii Gros Michel × M. ornata ..	2	3	nil
iv Gros Michel × Type 4 (Congo)	22	1	nil
v Gros Michel × I.C. 1.. ..	29	1	nil
vi Gros Michel × I.C. 2 ..	9	nil	—
vii I.C. 1 × I.C. 1 ..	117	18	3
viii I.C. 1 × I.C. 2 ..	42	3	nil
ix I.C. 2 × I.C. 1 ..	39	10	1

From the nature of the original problem direct pollination on Gros Michel was the first operation attempted in 1922 and throughout the period under review had priority. It may therefore seem surprising that only 125 bunches of Gros Michel are recorded in the table. The explanation lies mainly in the fact that all the land available is so heavily infested with *Fusarium cubense* that to grow this variety in quantity has been one of the greatest difficulties encountered. At the same time it must be remembered that the table does not include a large number of pollinations prior to 1927, from which several seedlings were raised. In 1932 it was decided that since extensive breeding on Gros Michel is being conducted by the Department of Agriculture in Jamaica, this line should be abandoned in Trinidad to avoid duplication of effort and allow concentration on other aspects of the problem. The figures given are therefore virtually final, so far as this programme is concerned. The crosses may best be discussed *seriatim*.

Crosses i-iii represent pollinations on the triploid Gros Michel by fertile diploid species, of which only one was used to an extent permitting conclusions to be drawn. *M. acuminata* here includes the plant called *M. malaccensis B* in former publications, and also other types, used to a less extent but referable to the same species. The cross Gros Michel × *M. acuminata* was fairly thoroughly explored, cytologically as well as genetically, and has been discussed in detail elsewhere (16). It gave a majority of tetraploid seedlings (2n=44) all closely similar in habit, and a few dwarf plants with narrow, wrinkled, somewhat fleshy leaves (2n=75 approximately, possibly 77). The latter were of no apparent use either directly or indirectly, and being difficult to keep alive were allowed to die. The tetraploid seedlings varied in physiological behaviour, and whilst some were as susceptible to Panama Disease as Gros Michel, others have hitherto proved completely immune. The first immune seedling raised was numbered I.C. (Imperial College) 1 and the second I.C. 2. Both were from pollinations prior to 1927, but later seedlings closely resemble them.

I.C. 1 is a vigorous plant, producing an edible fruit very much of the Gros Michel type, of similar storage properties and colour on ripening and of a pleasant though distinct flavour (61). The fruit is probably always rather smaller than that of Gros Michel, given equal growth conditions, and the bunch slightly less symmetrical. The chief commercial drawback of I.C. 1, however, is its increased fertility, which allows the formation of an occasional seed by natural pollination when it is grown in bulk. Its male flowers produce abundant pollen, but it is still highly sterile on the female side. The figures in the table (*Cross vii*) show the extent to which it produces seed when self-pollinated by hand. Almost identical figures were obtained when an area of about two acres was planted in a forest tract and left to natural pollinating agents; 119 bunches examined yielded 19 seeds of which 3 germinated. I.C. 1 therefore lacks the complete self-sterility necessary in a commercial type.

I.C. 2 in appearance is indistinguishable from I.C. 1, but may possibly prove free from the most objectionable character of that seedling. Our experience of it is not yet so extensive, but there is good evidence that its pollen though abundant is almost if not entirely impotent. Comparison of the reciprocal crosses viii and ix in the table shows a difference which is actually more marked than it appears. The ten seeds from the cross I.C. 2 × I.C. 1 were distributed in 8 bunches. The three from the reciprocal cross were all in one bunch, and occurred after 40 consecutive failures. I.C. 2 pollen has been used in other crosses, on *M. acuminata* among other types, and this is the only record of its setting a seed. There is thus a possibility that this particular bunch was mislabelled, the cross actually made being the reciprocal. I.C.2 is at present undergoing

extensive tests to confirm this point and at the same time to determine its agricultural behaviour. If its fruit grown under commercial conditions will attain a commercially acceptable size, it may possibly serve as a partial and interim solution of the Panama Disease problem, but whether it does or not its immediate significance is that its characters are sufficiently close to those of a good commercial banana to warrant attention. This indicates that tetraploid seedlings in general are not to be ignored as potential commercial types, and thus that combination of Gros Michel with other suitable diploid species beside *M. acuminata* is still a practical breeding method of great promise.

Cross iv represents a cross between two triploids. Type 4 (Congo) is one of the standard edible varieties in the Imperial College collection which happens to have rather abundant pollen. Under the name of Robusta what appears to be the same variety is reported to have been used as a male parent with considerable success in Jamaica (4). In Trinidad, however, both in this cross and in others, Congo has failed to give progeny, except for one weakly plant raised from a pollination in 1922. This apparent discrepancy in behaviour needs, and is receiving, further study. So far as Trinidad results alone are concerned, the evidence indicates that the use of triploid clones as male parents is not worth while so long as other methods remain to be explored. In this connexion it may be mentioned that Gros Michel pollen, which is moderately abundant, has been used on 16 inflorescences of *M. acuminata*, 6 of *M. ornata* and 37 of various edible bananas without a single seedling resulting.

Crosses v and vi represent back-crosses of the tetraploid seedlings to their female (triploid) parent. The negative results from these attempts are stronger than the table indicates, as many pollinations were made on Gros Michel by I.C. 1 prior to 1927. One plant indeed was raised in 1925, but it proved to be an aneuploid of obviously semi-lethal constitution and was kept alive until it flowered only with great difficulty. Even the figures given show that there is little promise along this line.

The back-cross of a tetraploid seedling to its diploid parent, not represented in the table, may be quite a different matter. I.C. 1 was back-crossed to *M. acuminata* when it first flowered in 1925, and the cross was effected readily in both directions. The progeny were triploid; fourteen individuals were examined and all showed $2n=33$, except for a possibility in three cases that the true count was 34. This progeny was of no commercial value, but the result was important as an indication of how new triploid combinations can be brought about. With a different diploid substituted for *M. acuminata* it is possible that useful triploids may be obtained.

Cross vii which concerns the self-fertility of I.C. 1 has been mentioned already. Including those raised from seeds obtained under natural pollination there were six F2 plants in all, of which one died and five were examined for chromosome number. Three were found to have $2n=44$ and two had $2n=46$ The population is small, but whilst it only indicates tentatively that tetraploids on selfing tend to give tetraploids, it also provides definite evidence that aneuploids may be formed in this generation, a piece of information which is not without value. The low fertility on selfing is also worthy of comment, as compared with the yield of seeds from the original triploid × diploid cross. The F2 plants are less like commercial bananas than their parent.

Crosses viii and ix are between sister plants, and might be expected to resemble *Cross vii*. The chief point of interest in them is the difference between the reciprocal matings, already elaborated above. The single plant resulting from *Cross ix*, like the five plants of the F2 from I.C. 1, is less like a commercial banana than its parents. It is desirable nevertheless that this cross, and others like it, should be repeated on a fairly large scale, in order that the economic value of crosses between closely related tetraploids may be more accurately estimated than the present data allow.

Outlook for further Breeding from Gros Michel.

The opinion was expressed in 1931 that "in breeding on Gros Michel there appears to be great hope if the best type of pollen to use can be found". Further experience has tended to strengthen that opinion and to confirm the need for a wider survey of possible pollen parents. *Musa acuminata* has two serious disadvantages as a parent of new commercial strains, one being the size of its fruit and the other the manner in which that fruit is borne. The small size of the fruit is perhaps the lesser defect, but it seems to be transmitted to some extent to the progeny, so that seedlings such as I.C. 1 and I.C. 2 have probably a genetically smaller fruit than Gros Michel itself, in which case they must always produce a smaller fruit under equal conditions. On the other hand it seems quite possible that such seedlings are able to produce a fruit of commercial size under reasonably good conditions. In the case of I.C. 2 the question is now being put to the test and definite pronouncement must await further trial. The manner in which the fruit is borne is very important. The inflorescence of a commercial banana must hang vertically, in order that the negatively geotropic bending of the "fingers" which takes place after flowering and whilst the fruit is growing may result in the development of a symmetrical cylindrical bunch. *M. acuminata* holds its bunch horizontally, or even at an angle slightly above the horizontal, so that it develops highly asymmetrically. This character also is transmitted to some extent to the progeny, and whilst in the best tetraploid seedlings such as I.C. 1 and I.C. 2 the departure from symmetry of the bunch may not be sufficiently serious by itself to condemn those clones, it is an inherent defect not to be ignored in attempts to produce better. In the back-cross of the tetraploids

which is necessary to restore the triploid condition, both defects of the diploid parent are accentuated, and the results obtained indicate strongly that so long as only *M. acuminata* is employed as diploid parent, no economic result is to be expected along this line.

Fortunately, *M. acuminata* is by no means the only diploid parent available. Since the close of the period of research under review four *Eumusa* species recently collected have been found to produce an almost vertical and symmetrical bunch, and two of them are superior to *M. acuminata* in size of fruit. It remains to be seen what kind of progeny each of these will give with Gros Michel, and whether any of them will transmit resistance to Panama Disease. It is worthy of note that none of the four fits the description of any well-known species, and they all await determination. One comes from New Guinea, one from Samoa, and two from Northern India. There appears a strong probability that still other undescribed *Eumusa* species await discovery in the Indo-Malayan region, and any one of them may well be a key to the Panama Disease problem.

2. Attempts to Breed from the Cavendish Group

The "Cavendish Group" is a term suggested by Cheesman, Wardlaw and Spencer (20) to cover a number of banana varieties closely similar in physiological and genetical behaviour and apparently related also on morphological grounds though somewhat diverse in superficial characters. In the Progress Report of 1931 (14) the term was used to cover only two varieties, Governor and Giant Chinese, now called Type 2 (Dwarf Chinese) and Type 3 (Giant Chinese) respectively. It was later extended to include also the whole of what was there called the "Congo Group".

The regrouping was a result of varietal studies, and took place in several steps. First of all fresh evidence came to light indicating that the varieties called Congo and Bolinaga were closely related to the Giant Chinese already placed in the Cavendish Group. Probably all three are bud-sports of the dwarf banana commonly called *Musa Cavendishii* (19). Next the remaining members of the "Congo Group" of 1931, namely Bumulan, Giant Fig and Lacatan proved to be identical; the name Lacatan was adopted and the synonyms were discarded. Finally it was concluded that the original grouping of Lacatan with Congo was sound, and that there was no logical reason for excluding Lacatan from the Cavendish Group, since it differed from the other members in nothing more fundamental than stature. After the publication of these conclusions (20) it was discovered that the tall Cavendish type widely known as Lacatan is not identical with the Philippine variety of that name described by Teodoro (57). Therefore in its adoption as Type 5 of the collection of standard clones the name Lacatan was rejected as unsuitable and its Malay name of Masak Hijau was coupled with the type number.

The Cavendish Group as now defined comprises four sub-groups. A dwarf sub-group contains all the dwarf bananas commonly referred to *M. Cavendishii*. It is still an open question whether these dwarfs are all of one variety or whether there are several closely similar forms included. All the pollinations reported, however, were made on a single type, the Governor banana of the West Indies, here called Type 2 (Dwarf Chinese). Two sub-groups are semi-tall, or in other words intermediate in stature between the dwarf and the general run of tall bananas, and differ mainly in a character which greatly modifies appearance but cannot be considered fundamental. Type 3 (Giant Chinese) resembles the dwarf in holding its faded male flowers and bracts on the rachis below the fruit-bunch. Type 4 (Congo) and Sub-type 4A (Bolinaga) shed their male flowers and bracts like the majority of tall varieties, and consequently appear at first sight more widely removed from "*M. Cavendishii*", but on closer study show very close affinities with it. The fourth sub-group is fully tall and contains at present only the single variety called Type 5 (Masak Hijau) formerly considered under several different labels.

The whole group is highly resistant to Panama Disease and by other characteristics commends itself to the breeder's attention scarcely less than Gros Michel. The Dwarf Cavendish (whether one type or several) is already the second banana of commerce, and Types 3, 4 and 5 have all attracted commercial notice experimentally. The fruit is suitable to the trade in size, shape and flavour, but its carrying properties are inferior to those of Gros Michel and the difficulties introduced by that fact have never yet been fully overcome. The alteration of genotype necessary to produce a first class commercial banana from any of the Cavendish clones would thus appear no greater than that involved in producing an "immune Gros Michel".

From these considerations, attempts to breed from the Cavendish Group have had a prominent place in the programme for some years, and because the varieties are easier than Gros Michel to grow at the College the pollinations actually made on them were much more numerous. The results are:

Table 2.

Female Parent.	Male Parent.	Bunches cut.	Seeds found.
Type 2 ..	M. acuminata ..	54	nil
Type 2 ..	Type 1 (Gros Michel)	7	nil
Type 2 ..	Type 4 ..	66	nil
Type 2 ..	I.C. 1 ..	9	nil
Type 3 ..	M. acuminata ..	17	nil
Type 3 ..	Type 1 ..	1	nil
Type 3 ..	Type 4 ..	5	nil
Carried for'd.		159	

Table 2.—*Contd.*

Female Parent.	Male Parent.	Bunches cut.	Seeds found.
Brought for'd.		159	
Type 4 ..	M. acuminata ..	20	1
Type 4 ..	Type 1 ..	1	nil
Type 4 ..	Type 4 ..	19	nil
Type 4 ..	I.C. 1 ..	16	3
Subtype 4A..	M. acuminata ..	21	nil
Subtype 4A..	M. ornata ..	1	nil
Subtype 4A..	M. sapientum ..	2	nil
Subtype 4A..	M. textilis ..	2	nil
Subtype 4A..	Type 4 ..	5	nil
Subtype 4A..	I.C. 1 ..	1	nil
Type 5 ..	M. acuminata ..	260	8
Type 5 ..	M. sapientum ..	12	nil
Type 5 ..	M. textilis ..	5	nil
Type 5 ..	Type 1 ..	15	nil
Type 5 ..	Type 4 ..	49	nil
Type 5 ..	I.C. 1 ..	29	nil
Type 5 ..	I.C. 2 ..	1	nil
		618	

The table shows at a glance that the whole group is for practical purposes sterile, and the failure of attempts made on this scale indicates that future efforts will be much more profitably directed elsewhere. A few figures in the table call for comment:

Of 618 bunches cut, 612 were seedless. In 372 cases *Musa acuminata* was the male parent, and this species has proved in other cases an excellent "analyser" of seed-producing potentialities, yet 367 were seedless. Furthermore, in nearly every case where seeds were recorded there was a possibility of error. The single seed from the cross *Congo* × *M. acuminata* was probably genuine but did not germinate. The three seeds from Congo × I.C. 1 were all in one bunch, and a note in the pollination book shows that there was some doubt of the entry at the time it was made; in any case none germinated. The eight seeds reported from Type 5 × *M. acuminata* can be readily accounted for. They were distributed in four bunches, all of which were traced to a certain field in which Type 5 under the label "Lacatan" was growing alongside Gros Michel. This field was not part of the breeding plots, but was used because the cross Lacatan × *M. acuminata* was at the time being made on a large scale and every inflorescence was wanted. There is little doubt that four bunches of Gros Michel were pollinated by mistake as "Lacatan", a mistake very easily made between those two very similar varieties. The conclusion is supported by the facts that 91 bunches of Type 5 under other labels were all seedless, and that there were 51 consecutive failures on "Lacatan" before the seeds were found and 48 afterwards, when particular care was being taken to check the result. Only one of the eight seeds germinated, and it gave a thick-leaved dwarf plant of undeterminable parentage, exactly like the 75-chromosome seedlings obtained from Gros Michel. Thus in spite of a regrettable break in an otherwise conclusive set of data, the complete sterility of Type 5 to every kind of pollen tried may be stated with confidence, and the failure of the Cavendish Group to give useful progeny in these experiments is absolute.

Even so, it is proposed to continue trials on a smaller scale with new kinds of pollen as such become available, since there is always the possibility that these clones may be fertile with some species not yet discovered—(*To be concluded*).

MISCELLANEOUS NEWS.

Mr. S. H. Evelyn, Cotton Officer, St. Vincent, sailed on 15th April for England where he will spend three months vacation leave.

* * *

Mr. A. K. Briant paid a visit to Montserrat from 11th to 28th April for the purpose of investigating a disease affecting lime trees.

* * *

Mr. A. K. Briant has been selected by the Secretary of State for the Colonies for the appointment of Agricultural Superintendent in St. Vincent.

* * *

Dr. Hutson, Government Veterinary Surgeon in Antigua gave three lectures on "The Animal" to Primary School teachers during the month of April.

* * *

Mr. Glasgow, Agricultural Officer, St. Lucia, proceeded to Jamaica on 25th April in order to obtain information on the methods of cultivating and handling bananas in Jamaica. The assistance given by the United Fruit Company which bore the expenses of his tour is much appreciated.

Mr. F. G. Harcourt, Agricultural Superintendent, Dominica, sailed for England on 27th April. He has been granted vacation leave from 27th April to 3rd September to be followed by leave on half pay until 3rd October.

* * *

Mr. G. A. Jones, Commissioner of Agriculture, left Trinidad for England by the s.s. *Bayano* on 12th June on three months vacation leave. During his absence Mr. A. C. Shill, Marketing Officer, will act as Commissioner of Agriculture in addition to carrying out his usual duties. Mr. Shill arrived in Trinidad on 28th May.

* * *

The Advisory Board of the West Indian Sea Island Cotton Association held its first meeting in London on 14th March,. The Earl of Plymouth, Acting Secretary of State for the Colonies was present and opened the proceedings. Mr. H. Astley Bell, J.P., was elected Chairman of the Board. Other meetings have since been held on 11th April and 3rd May.

WEST INDIAN NOTES.

(Compiled by the Advisory Department, Imperial College of Tropical Agriculture.)

Sugar-cane Experiments in Antigua and St. Kitts.

ANTIGUA.

A preliminary programme of field experiments on sugar-cane in Antigua has been drawn up by Mr. P. E. Turner for the 1933-35 and 1934-36 crops of plant canes, and the 1933-34 crop of ratoon canes. The scope of the programme is extremely wide, and is further complicated by the experiments being repeated in different types of soil. The experiments are grouped under the following operations:—

1. *Preparation of the Land for Planting.*

Three series of experiments are proposed in which the land will be cultivated in different ways using, (*a*) a Gyrotiller drawing a grading body, (*b*) tractor ploughs, and (*c*) cattle ploughs. In other experiments the relative merits of planting in cross-holes and in open furrows will be compared on both light and heavy land.

2. *Planting.*

Experiments are being made to determine the optimum (*a*) time of planting, (*b*) distance of planting and (*c*) type of spacing.

3. *Cultural Methods after Planting.*

Under this heading, two series of experiments are included. In one series, the effects of breaking and not breaking the banks will be compared under different sets of conditions, namely, with and without dressings of sulphate of ammonia followed by farming and cultivating (*a*) by hand and (*b*) by animal drawn implements. The second series relate to moisture conservation and weed control in the presence and absence of dressings of sulphate of ammonia. Comparisons will be made between the effects of mulching with trash, and farming and cultivating (*a*) by hand and (*b*) by animal drawn implements.

4. *Manuring.*

The manurial experiments are designed to determine (*a*) the optimum size of dressing of pen manure, (*b*) the relative value of dressings of pen manure and inorganic manures, (*c*) the relative value of different dressings of inorganic manures, (*d*) the value of filter press mud as an alternative to purchased organic manures, (*e*) the best manurial treatment for un-pen-manured soils, and (*f*) the form of nitrogen best applied to alkaline soils (sulphate of ammonia or nitrate of soda).

5. *Soil Amelioration.*

The object of these experiments is to determine what benefits would accrue from applications of (*a*) ground limestone, (*b*) green dressings and (*c*) pen manure and sulphur (in accordance with the suggestions of Prof. F. Hardy, Mr. J. A. McDonald and Mr. G. Rodriguez).

6. *Variety Trials.*

Comparative tests of the varieties B.4507, Ba.11569, S.C.12/4, B.2935, G.119, P.O.J.2878, B.726, B.H.10(12) and B.6308, are being made under different soil and rainfall conditions, as recommended by Dr. A. E. S. McIntosh. In addition comparative tests of the varieties Co.213, P.O.J.2878, B.H.10(12), Ba.11569 and P.O.J.2727 are being carried out on infertile soil types, according to the suggestions of Mr. C. F. Charter.

All the above experiments are in the charge of the Agricultural Superintendent, Mr. F. H. S. Warneford, and of Mr. C. F. Charter who is working for a group of estates. A full description of the experimental scheme, and of the relationship it bears to agricultural practices in Antigua, are recorded in a paper entitled "A Critical Review of Agricultural Practices in Antigua with Special Reference to a scheme of Field Experiments", which is being published by the Sugar-Cane Investigation Committee of Antigua.

* * *

ST. KITTS.

A programme of field experiments has also been drawn up for the 1934-36 crop of plant canes and the 1934-35 crop of ratoons canes in St. Kitts. The experimental programme relating to the 1933-35 plant canes has already been discussed in these notes in the January, 1934, issue of *Tropical Agriculture*.

The new set of experiments includes investigations concerning:—(*a*) Optimum time of planting, (*b*) the relative value of planting in cross-holes and open furrows, (*c*) the optimum dressing of (1) sulphate of ammonia, (2) potash, (3) phosphate and (4) ground limestone, (*d*) the optimum depth of ploughing and (*e*) the value of mulching with megasse.

A series of variety trials based on the suggestions of Dr. A. E. S. McIntosh, are also being undertaken.

A complete description of this experimental scheme is being published by the Sugar Cane Investigation Committee of St. Kitts.

* * *

Arrowroot Problems in St. Vincent.

Mr. C. K. Robinson who was appointed Scientific Officer to the St. Vincent Arrowroot Association in November 1932, to investigate problems affecting the Arrowroot industry, has recently reaped several of the preliminary experiments which he laid down in 1933.

The problems which he is endeavouring to solve are very varied, and before some of the solutions are obtained experiments will have to be continued for several years. The results already obtained however form a valuable foundation for future work as they indicate the lines along which further enquiries should be made. An outline of Mr. Robinson's work is given below:—

(1) The collection and study of possible varieties or types with a view to discovering high yielding strains.

(2) The determination of what type of planting material produces the best results, *e.g.*, whether the "bits" should consist of one, two or more nodes, and from what type of rhizome they should be selected, fat or thin, long or short jointed &c.

(3) The effect of different planting distances on yield. Under the conditions of an experiment conducted during the past season the best results were obtained from plants planted six inches by six inches apart.

(4) The effects on yield of different types of mulches applied during both wet and dry seasons. During the past season an average increase of 30 per cent. or more in crop yield was obtained by the application of wet season mulches. Both leguminous and non-leguminous plants were used as mulches, and practically the same increase in yield was obtained in each case. Further work to determine whether the action of the mulch is chemical or mechanical and whether the same effects could be produced in a cheaper way would be of great importance.

(5) The influence of artificial fertilizers and pen manure, applied alone and in different combinations. In a series of four experiments, pen manure applied at the time of planting followed by a top dressing of Sulphate of Ammonia at the time of flowering gave the best results. The next largest yields were obtained by the application of a complete dressing of artificials at the time of flowering. Applications of pen manure alone, and pen manure with Potash and with Phosphate gave relatively small increases. From the profit and loss point of view pen manuring is much inferior to treatment with a complete dressing of artificials under the conditions of the experiments.

(6) The investigation of problems concerning the arrowroot "worm" *Calpodes ethlius*. The life-history of this pest has been studied by Mr. Robinson, and the observations previously made by Mr. F. W. Urich have been confirmed. Several parasites on *Calpodes* have been recorded in St. Vincent, the most important being *Trichogramma sp.* in the egg stage, and species of Tachinid flies in the late larval stage. No parasites have yet been found to attack the pupae or adults.

To determine whether the defoliation of arrowroot by *Calpodes* is a serious matter or not, an experiment is now being carried out in which the plants in certain plots are defoliated by human agency. If necessary, attempts to control *Calpodes* may then be made either by the mass rearing of *Trichogramma* or by the introduction of parasites from elsewhere.

(7) The determination of the cause of the production of "cigar-roots". Work during the past season indicated that the type of material used for planting influences to a large extent the type of rhizome produced, irrespective of manurial treatment, or possibly soil conditions. An experiment has recently been laid down to determine whether the cause is genetic or physiological.

Subsequent to Professor Hardy's visit to St. Vincent in April, 1933, the Chemistry Department of the Imperial College of Tropical Agriculture has undertaken the analysis of soil from areas producing normal and "cigar-roots", but the results of this work are not yet available. Mr. Robinson believes that if the cause of "cigar-root" is physiological it is probably due to a combination of soil conditions and type of planting material.

* * *

Cotton in Carriacou.

Dr. Harland, Cotton Adviser to the Commissioner of Agriculture, has recently submitted a report on his visit to Grenada and Carriacou from 13th to 20th April. The main object of his visit was to inspect the propagation and experimental plots of the long-staple Carriacou and Moco cotton selections in Carriacou. During the last few years the Agricultural Assistant, Mr. F. Simmons, who is in charge of these plots, has been making selections from the Carriacou type of cotton, and has now obtained several new strains which appear to be very superior to those ordinarily grown. The selections have a mean maximum lint length varying from about 46 to 51 mm. Although some strains may later be discarded, and the results of spinning tests have not yet been received, Dr. Harland has recommended that the large scale propagation of seven substrains should be immediately undertaken in order to replant the whole of the cotton-growing areas in Carriacou with the new types in the next two years. With this end in view the Government has made arrangements to rent 100 acres of land in 1934 for propagation and demonstration purposes, so that sufficient seed will have been produced in 1935 to plant 2,000 acres, and in 1936 to effect the complete substitution.

* * *

St. Vincent Agricultural Credit Societies Ordinance, 1934.

The ordinance relating to Agricultural Credit Societies passed in St. Vincent in 1913 was the first ordinance of its kind to be enacted in the West Indies, and formed a model on which similar ordinances in Trinidad and St. Lucia were first based. Conditions in Trinidad have, however, since led to the ordinance being considerably modified, and in consequence the revised Trinidad ordinance has recently been used as a basis for drafting a new ordinance enacted in St. Vincent in February, 1934.

One of the chief features of the new law is that a Credit Society making a loan now has a lien on the property of the borrower by which the loan is secured. The ordinance has been considerably enlarged by the addition of an appendix consisting of eight schedules which define in considerable detail the conditions under which Credit Societies will be accepted for registration.

The Fruit and Vegetable Industry.

The banana developments which were outlined as being forthcoming in the last quarterly notes have now materialised to a considerable extent. Local Banana Associations were incorporated by ordinance in St. Lucia and Dominica at the end of March and contracts were signed with the Canadian Banana Company at the end of March and early April respectively. Grenada (where contracts were signed direct with estate owners) and St. Lucia began shipping under the new conditions on March 26th and Dominica followed suit three weeks later. Following a survey of banana possibilities of St. Vincent carried out in March by Dr. V. C. Dunlap of the United Fruit Company, a similar contract was offered by the Company: the ordinance incorporating the local Banana Association was passed on June 8th and it is expected that the contract will be signed about the middle of June, although it will not immediately become operative owing to the very limited quantities of fruit at present available. Largely owing to the present shortage of space, the fruit from Trinidad, where a similar contract was signed in April, has been sent to England on all but one occasions, (1,447 stems to Canada in May).

The quantities shipped up to the end of May are tabulated below. Shipments to Canada were curtailed considerably until the end of March owing to the change over from still-air grid to forced-draught cold storage on the Canadian National Steamships.

Island.	Jan. & Feb.	Mar.	April.	May.	Total.
	stems.	stems.	stems.	stems.	stems.
Trinidad ..	5,908	4,228	2,351	4,727	17,214
Dominica ..	2,582	—	1,802	1,333	5,717
St. Lucia ..	2,130	925	1,113	837	5,005
Grenada ..	—	974	558	1,848	3,380

Rapidly increasing exports are expected, particularly from Grenada and later from St. Vincent, the prospects in these two islands being more favourable owing to better soil conditions and relative freedom from Panama Disease. In this connection it is expected that additional banana carrying space will soon be installed on the Canadian National Steamships. In Grenada extensive planting is in progress and in St. Lucia the Government is starting four nurseries, each of about four acres, it being considered that the provision of cheap, easily accessible, disease-free material for the peasants is the best method of minimising the spread of Panama Disease under local conditions.

The growing of tomatoes this year was, except in Nevis, limited to production for the late market, that is, for shipment from March onwards. Owing to dry season conditions the amount of land suitable for late market production is limited, and this, in conjunction with the shorter season, has resulted in decreased exports. The exports this season to the end of May from Montserrat totalled the equivalent of about 6,500, 20-lb. lugs (1932; 19,600: 1933; 11,500) and St. Vincent shipped during the same period some 800 lugs (1932; 8,800: 1933; 1,900). All the details of sales are not yet available but the average net return to the growers after deducting packing, shipping and marketing expenses should be at least two cents per pound. Since the majority of the fruit is peasant grown, this return, particularly in Montserrat with the generally higher average yields, is fairly satisfactory. The small Nevis exports of 300 lugs made over the period December to March (1932-33; 1,350 lugs) gave fairly satisfactory returns; owing to dry season conditions, production for the late market in Nevis is not feasible.

The New York lime market continued to be very remunerative, owing to shortage of supplies, up to the middle of May, local prices for loose, selected limes being around $5.00 per barrel but prices have recently begun to drop as is usual at this time of year. Shipments in barrels to New York to the end of May were as follows, the shipments over the same period in 1933 being given in brackets:—St. Lucia 851 (503), Dominica 760 (1,185) and Montserrat 671 (none). A noticeable feature is the increase in exports from Montserrat. Shipments to Canada started with the export of 925 lugs during May from Dominica, Montserrat and St. Lucia (c.f. 406 to the end of May in 1933) and further expansion of this market during 1934 is anticipated.

The Montserrat onion crop has shown an all-round improvement this year, and 1,248 bushels were shipped to the end of May as compared with 910 bushels in 1933. Small shipments have also been made from other islands. All the onions have been sold in the West Indies, mostly in Barbados and St. Lucia, and the prices have been fairly well maintained owing to competition with Egyptian onions being relatively less severe than usual. The quality and curing were noticeably better than in 1933.

Shipments of carrots and sweet potatoes from Montserrat to the end of May totalled 642 bushels and 770 bushels respectively, most of these vegetables being shipped to Canada. Owing to blackening and wastage developing in cold storage en route the sweet potato shipments were generally unsatisfactory.

The mango season is now well started in St. Lucia, and shipments to Bermuda totalled (to end of May) 1,006 crates (same period 1933; 1,424 crates). Shipments from Dominica have, however, only totalled 173 crates, the season in this island being as usual later than in St. Lucia. The grafted mango crop is late this year: weather conditions induced several small settings of bloom rather than one main setting and consequently the crop will extend over a longer period and will not show the increase expected with more of the topworked trees coming into bearing.

BREVITIES.

Arrangements have been completed by the Governments concerned for the purchase of Jonas' Estate in Antigua and Hamilton's Estate in Nevis, both of which are to be used for land settlement purposes.

* * *

The cacao pods introduced into Dominica and St. Lucia (above mentioned) are of special interest as they were obtained from some of the trees specially selected by the officers of the Cacao Research Scheme for their high yielding and high quality characters. The seed germinated very well and the progeny obtained from the different trees will be planted out separately so that observations can be made as to what extent the good qualities of the parents have been transmitted.

* * *

During the last six months the Advisory Department has arranged for the following planting material to be sent to the islands mentioned:—*St. Vincent*, a barrel of B. 2935 cane cuttings from Barbados; *St. Lucia*, a barrel of Co. 213 cane cuttings from the Imperial College of Tropical Agriculture, and cacao pods from Trinidad; *St. Kitts*, roots of Java grass, and a barrel of Jamaican ginger from Trinidad; *Montserrat*, six varieties of sweet potatoes B.1, B.4, B.6, B.7, B.9, and B.11 from Barbados; and *Dominica*, a bag of Tonca beans and cacao pods from Trinidad.

* * *

In most of the Islands, agricultural officers devote a considerable amount of time to agricultural education. In Antigua and St. Kitts courses of lectures are given to estate overseers; in St. Kitts and Montserrat, Grammar School pupils are given regular tuition in elementary science; in Antigua and Montserrat a course of lectures has been given to elementary school teachers. In Dominica, St. Lucia and Montserrat a number of boys are taken each year and are attached to the Agricultural Departments as pupils. An article on the training of pupils in Dominica will probably be published in *Tropical Agriculture* in the near future.

* * *

A meeting of the Executive Committee of the West Indian Sea Island Cotton Association was held in Montserrat on April 16th and 17th, and was attended by the following:—Mr. G. A. Jones, President, Messrs. A. Moir Reid (St. Kitts), E. Dew (Antigua), A. de Lisle Inniss (Barbados), A. M. Hazell (St. Vincent), H. Shand (Montserrat) and A. K. Briant, Honorary Secretary-Treasurer. At this meeting the Montserrat Cotton Growers Association was given permission to export 360,000 lb. of lint of the 1934 crop and in addition, to export unlimited quantities on direct sales, subject to the production of satisfactory evidence to a local committee to be set up by Statute, that such exports are direct sales.

OBITUARY.

JOSEPH JONES, O.B.E.

It is with deep regret that the sudden death of Mr. Joseph Jones in Dominica on 1st May has to be recorded. He was born in Cheshire, England, on 27th February, 1867, and obtained his training in agriculture at the Royal Botanic Gardens, Kew.

In 1892 he was appointed Agricultural Superintendent of Dominica and Curator of the Botanic Gardens which, though commenced only one year before, were acknowledged at the time of his retirement in 1925, to be amongst the most beautiful and noteworthy Gardens in the West Indies.

During his 33 years in office, Mr. Jones played a most important part in the agricultural development of Dominica, particularly in connection with the lime industry in which Dominica occupied the unique position of being the world's chief producer. The peak year occurred in 1921, when it was estimated that lime products equivalent to over half a million barrels of fruit were exported. A large number of the trees producing this crop were raised and distributed by the Agricultural Department, whilst the Lime Experiment Station, opened in 1913, was able to advise planters in the correct methods of cultivation. This Station established plots of limes budded on sour orange stock which have to this day survived hurricanes and the effects of red root disease which caused the destruction of all the plots of seedling limes. This method of propagation is now in general use throughout the island. It is most fitting that Mr. Jones should have been buried in the old Military Cemetery next door to these plots, and in the midst of the Experiment Station where he laboured for so many years.

It is impossible to touch on all the varied activities of the Agricultural Department during this period, but it may be mentioned that Mr. Jones was responsible for the successful introduction of many useful and ornamental plants to Dominica, and for the distribution of hundreds of thousands of selected economic plants of improved quality and bearing capacity. He was also the pioneer of budding, as distinct from grafting, of cacao.

Such was the esteem in which Mr. Jones was held on his retirement, that he was petitioned by the leading planters and merchants to continue in office for a further period; but this he was obliged to decline on account of ill health. Shortly after his retirement the honour of Order of the British Empire was conferred on him for his long and meritorious service.

He continued to reside at Morne Bruce, overlooking the Botanic Gardens, where his valuable advice was much sought after by members of the planting community right up to the time of his death.

H. B. P.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

*** Commercial Analysis of Molasses for Use in the Distillery.**—*By E. Saillard.*

Sugars present in molasses sold for fermentation purposes are found as follows: Dilute 250 grms. molasses to about 500 c.c.; acidify so that 1 litre will contain 2.5 grms. of free sulphuric acid; boil 15 minutes; cool, and make up to one litre with distilled water at 30 to 32° C.; transfer to a 2-litre flask; add 5 grms. of fresh compressed yeast; close the flask with a cork bearing a glass tube loosely stuffed with cotton wool and set aside in a place where the temperature will remain at 30° C.

When fermentation is complete, determine the acidity, distil, and determine alcohol in the distillate at 15° C. Weigh the flask from time to time to observe the progress of the fermentation. The gas evolved during fermentation should be bubbled through water to recover alcohol vapours, this water being added to the flask before distillation. The author notes that the direct polarization of the slop defecated with lead subacetate is equal to the acid polarization after inversion, which proves that the rotation of the active non-sugars is not changed by the inversion with hydrochloric acid.—(*Int. Sugar Jr.*, Vol. XXXVI, No. 425, 1934, pp. 200.)

* * *

Separate Clarification of Last Milk Juice.—*R. H. King*, and *E. Villareal.*

During the 1932-33 season, twelve tests were made on the classification of the last mill juice obtained at Pampanga from different varieties of cane and with varying amounts of maceration water. Approximately 50 gallons of last mill juice from the last mill juice pump was divided into seven portions and limed to different pH's, heated to 100°C., samples being placed in narrow cylinders and the rate of settling, turbidity and colour noted.

In summarizing the data obtained in the 12 tests it is seen that in test No. 1 the greatest increase in purity was obtained by liming the juice to pH 8.29. This increase amounted to 1.83 points in the gravity purity. This juice was not clear. In test No. 2 in which the juice had the lowest purity, the greatest increase in purity amounted to 3.32 points at pH 7.5. At pH 8.8 the purity had decreased to nearly that of the untreated juice but from a standpoint of clarity and rapidly settling and column of mud the defecated juice at this pH was the best. In practically all tests the maximum increase in purity did not coincide with the maximum clarity, rapidity of settling and compactness of mud. This condition was reached at pH's above ten.

This investigation therefore indicates that the turbid non-settling matter is more completely eliminated from the last mill juice by liming to pH values above ten. There is a greater elimination of non-sugars by high liming, while the volume of mud is less (as it is more compact) at the higher alkalinities. There is a gradual elimination of gums after 8.5 pH. Due to the large increase in CaO, it would be advisable to heat the last mill juice to approximately 90°C. and to use the clear juice to temper the primary or combined crusher and first mill juices. The destruction of sucrose and glucose in the very alkaline juice is reduced by reducing the temperature. Good clarification can be obtained at 90°C.

It is believed that by combining the last mill juice with the mud coming from the settling tanks, liming to 10 pH and settling this mud and juice in the re-settlers, and the use of the re-settled juice for tempering the mixed juice, a considerable improvement in clarification can be accomplished. Such a division of juices and partial division of the maceration water will involve difficulties in the control, which can be overcome by separate weighing of the juices. (*Int. Sugar Journal*, Vol. XXXVI, No. 432, March, pp. 126.)

* * *

***Phosphate Fixation in Hawaiian Soils.**—*By F. E. Hance.*

In certain districts in the Hawaiian Islands the soils are distinguished by a greater or smaller tendency to 'fix' phosphate applied to these soils for fertilizing purposes; that is the P_2O_5 contained in these fertilizers is gradually transformed into an insoluble condition in which it is more or less unavailable to the roots of the plants. The reason for this fixation of phosphates is not entirely clear but it seems to be due to some property of the colloidal material of the soil; it is especially likely to occur where the ratio of silica to alumina and iron in the soil is low; hence addition of soluble silica to these soils tends to counteract fixation, but this use of silica is not very practicable on account of the expense. Application of molasses to the soil also tends to improve the effectiveness of phosphate fertilizer.

The author offers various suggestions as to how to secure results from phosphate fertilizers on such soils. It appears that reverted phosphate, which is soluble in water with difficulty, can be taken up by the cane roots; owing to its relative insolubility, it can supply the needs of the plant before the colloidal particles of the soil can make it unavailable. Another suggestion is that phosphate fertilizers be applied to the soil in granulated form or as 'briquettes'; these granules are mixed with the soil and are surrounded by the roots of the cane, which appropriates the phosphate before it can leach away and become fixed in the soil.—(*Int. Sugar Jr.*, Vol. XXXVI, No. 425, 1934, pp. 198.)

* Abstracted from the International Society of Sugar-Cane Technologists.

* Abstracted from the International Society of Sugar-Cane Technologists.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Storage of Citrus Oils.

Essential oils used for flavouring confectionery, mineral waters, &c., are delicate products. Changes however slow, are always taking place in these oils, with a detrimental result to their flavour and possibly their solubility. Light and warmth are conditions which help such changes in which air and moisture play a part.

What really happens is not definitely known, but it is certain that to keep essential oils in good condition for reasonably long periods the following conditions must be observed. The oils must be kept in the dark, in a cool place and free from moisture and in the absence of air.

Glass containers are most suitable for small quantities, but dark-coloured glass is not a protection against light sufficient to ignore the necessity for storing in a dark place. Metal containers are used for larger quantities, but the choice of metal is important. Iron has a definite detrimental effect on the oil flavour, while aluminium is liable to become corroded in time. The so-called "copper" has been found to give the best results, and for the lining, the tin used must be pure.

Absence of air for all practical purposes can be ensured by completely filling the bottles. In drums the replacement of air by carbon dioxide is about the only way possible. Stabilisers having anti-oxygen properties have been tried with various citrus oils, but the results have not been successful.

One of the most effective ways to ensure the keeping qualities of citrus oils for a reasonably long period is to add five to ten per cent. of strong alcohol to the oil. This addi ion probably prevents the moisture exerting its usual action, and it also retards the development of the turpentine-like flavour so characteristic of old or badly-stored oils.—(*Food Industries Weekly*, 1934, p. 18.)

* * *

New use for Tea Seeds in Java.

Among the native tea growers in Java the recently enforced tea restriction scheme has created great distress, which seems likely to continue until they return to their former agricultural pursuits. With a view to helping these growers, a former headman has been experimenting with tea seed kernels and has discovered that an edible oil can be extracted similar in colour and viscosity to honey. He reports that the substitution of tea seed oil for coconut oil—the common culinary oil in the East—in frying chicken made no difference in taste and was more economical in use.

Even the refuse of the kernel, which is harmful to fish and should not be thrown into streams and ponds, has its use. After soaking this refuse in tepid water for half an hour it was found that the mixture produced was a substitute for washing-soap. A Javanese farmer's shirt was successfully treated with this mixture, but it is not recommended for finer materials, owing to its injurious effects. If the refuse from tea seeds has cleansing properties the tea seed oil may be equally useful in manufacturing soap. And as the oil has been found to have a boiling point higher than that of peanut oil or coconut oil it may be found adaptable as a lubricant.—(*Times Trade and Engineering Supplement*, Vol. XXXIII, No. 807.)

* * *

Rubber-Growing Research in the U.S.S.R.

A determined attempt to make Russia independent of imported rubber in a few years' time is being made by investigating the possibility of home-grown rubber, and by the manufacture of "synthetic rubber"; four factories are already engaged in the industrial production of the latter. Research on the growing of rubber is carried out at two rubber institutes working in conjunction with the Institute of Plant Industry. Expeditions have been sent out to search at home and abroad for suitable rubber-bearing plants, the indigenous flora having been particularly carefully surveyed.

The three most promising plants so far appear to be *Parthenium argentatum*, Gray, *Scorzonera tausaghis*, and *Taraxacum gymnanthum*, D.C. The first-named, the guayule, brought from Mexico, has been the subject of several investigations*. This plant has several varieties, differing in rubber content, resistance to drought and cold, and also in the quantity and germination of seed production; easy propagation by seed is important for the economical production of rubber from this type of plant.

Scorzonera tausaghis grows wild in Central Asia, and was first described by the staff of the Institute in 1931. It is a slow-growing perennial, very readily reproducing itself vegetatively and is rich in best quality rubber. *Taraxacum*, a biennial, occurs in the south of the Crimea. Lomzan, Kotov and Tcherkacov have described the last two†. These indigenous plants have not been under observation so long as the guayule, but are considered very promising owing to the high quality of their rubber and the ease of separating it. The two native plants are also note-worthy for a low proportion of resin to rubber, and the fact that the rubber contained in them is in the form of fine threads; this form of occurrence has not been encountered previously by the investigators.

Experimental plantations of the first two plants named above are in existence, many of them large enough to enable the trials to be carried out on a commercial scale. It has been planned to have more than 500,000 hectares under rubber cultivation by 1937.—(*Nature*, Vol. CXXXIII, No. 3362, 1934, pp. 539-40.)

* Nickolaev, Astrov and others, *Bull. App. Bot.* 22, 4; 1929; 2, 3, 1932, &c.

† *Nature* (translation of the Russian title), 2; 1933.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.)

	Foreign.	*Preferential.*
	s. d.	*s. d.*
26th April	4 9¾	8 6
3rd May	4 10½	8 6¾
10th May	4 9	8 6¾
17th May	4 8¼	8 3
24th May	4 9¾	—
31st May	4 7½	8 7½
7th June	4 7½	8 7½
14th June	4 7½	8 9
(15*th June*, 1933)	5 10½	10 7½

Developments in America have again monopolised the attention of World Sugar markets, and particular interest was shown in the long-delayed passing of the Sugar Control Bill and Sugar Tariff by which the General Duty on sugar was reduced from $2.50 to $1.87½, and the Cuban Duty from $2.00 to $1.50. Since then an absence of any development of major influence on the market has given to it a somewhat listless tone, and attention is now being turned to the new season's prospects. Next year's crop in Cuba according to current belief, will not exceed 2,000,000 tons.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:

	d.
25th April	5 15-16
2nd May	5 31-32
9th May	7 1-16
16th May	6 3-16
23rd May	6
30th May	5 7-8
6th June	6 1-4
13th June	6 9-16
(14*th June*, 1933)	3 3-8

The event of outstanding importance since our last report has been the successful outcome of negotiations for the regulation of output and export of Raw Rubber, by which quotas have been assigned, subject at any time to alteration by the Committee, to the principal exporting countries. Further planting of rubber has been prohibited, whilst the minimum duration of the agreement is from 1st June, 1934, to 31st December, 1938. The scheme met with good reception from the start but following a period of fluctuations the market has shown some inactivity pending legislation proceedings in connection with the agreement.

* * *

COFFEE.—The demand for Spot supplies of coffee has been consistently poor. The small part sold realized about steady prices, and latest quotations per cwt. for Costa Rica, London cleaned, bold coloury, were 94*s.* 6*d.* to 100*s.* 6*d.* Brazilian kinds were quiet and unchanged; Superior Santos, prompt, quoted 47*s.* f.o.b.

COCOA.—The cocoa market is firm due to continued activities of Exchange speculators which is enabling sellers of actuals to dispose of their holdings despite the large visible stocks on hand. The last quotations were as follows:—new crop Accra 24*s.* 9*d.*, Bahia 24*s.* C. & F., San Thome 24*s.* c.i.f. and locally $7 a fanega.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

COPRA.—Has continued steady and West Indian f.m.s. is a further 2*s.* 6*d.* higher at £9 7*s.* 6*d.* c.i.f. London.—(*West India Committee Circular*, 24th May.)

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:—

	American Mid.	*Egyptian F.G.F. Sakel.*
27th April	5.88	8.07
4th May	5.93	8.18
11th May	6.15	8.50
18th May	6.23	8.45
25th May	6.20	8.42
1st June	6.30	—
8th June	6.51	—
15th June	6.75	—
(16*th June*, 1933)	6.18	8.30

Prices declined on account of the disappointing final form of the Bankhead Bill, President Roosevelt's opposition to silver legislation, and the unlikelihood of further inflation for the present. Later prices became steadier, though business done was very small.

* * *

BANANAS.—Jamaicas have been in good demand and both the Jamaica Producers and Elders & Fyffes have until recently continued to quote to wholesalers £19 5*s.* per ton delivered London and £19 nearest station Provinces; the former have since announced an increase in their prices of £1 per ton. Brazilians are in good demand and 10*s.* higher at £18 per ton.—(*West India Committee Circular* 24th May.)

* * *

GRAPEFRUIT.—The average prices ruling in Covent Garden for the week ended 19th May, according to count and condition were:—

	s. d.	*s. d.*
Jamaica	11 0 to 16	0
California	14 0 to 18	0
Puerto Rico	15 0 to 19	0
Trinidad	14 0 to 21	0

The Trinidad season came to a close on 20th April, when 1,002 boxes were shipped.—(*West India Committee Circular*, 24th May.)